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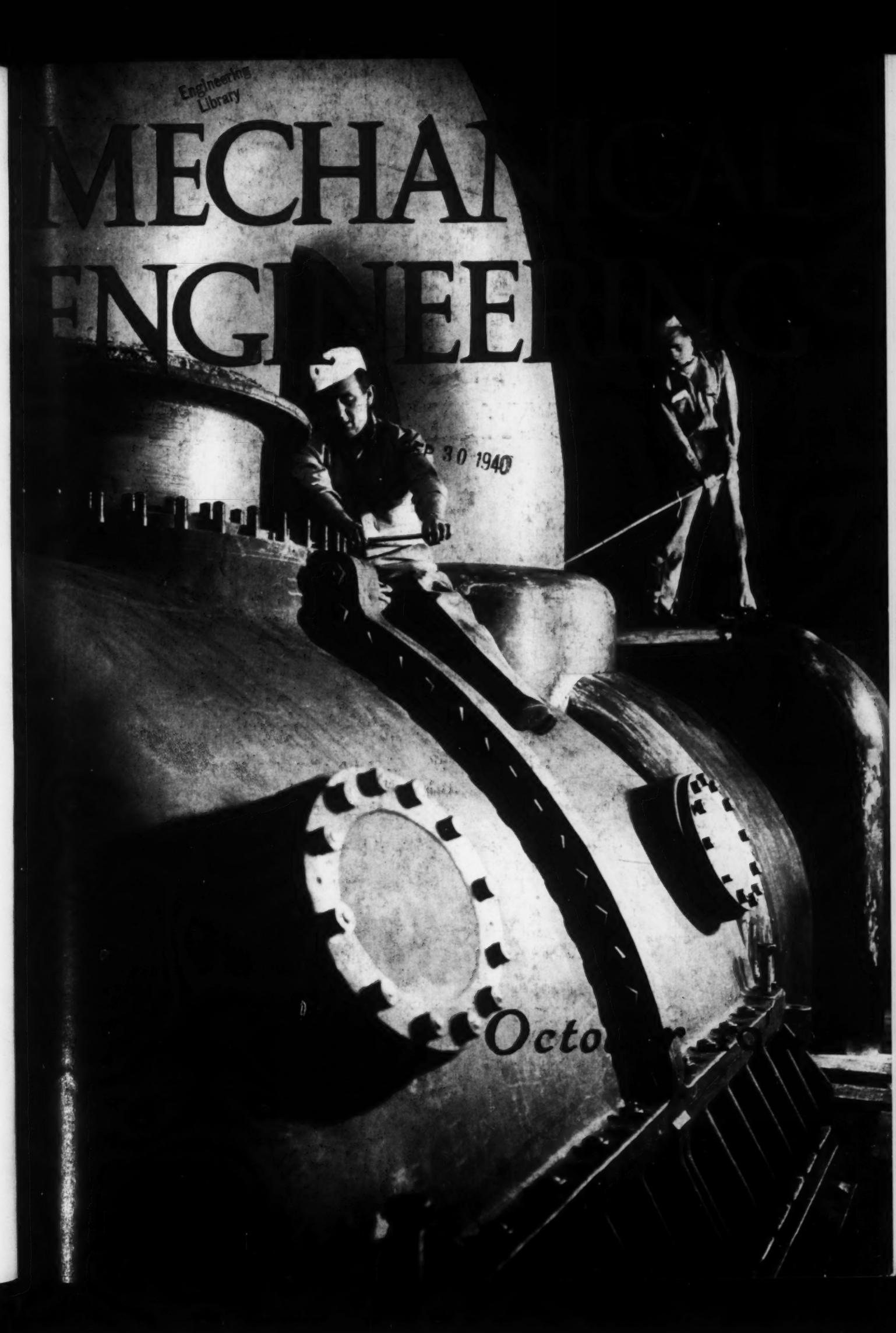

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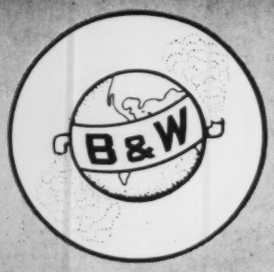

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MECHANICAL ENGINEERING

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VOLUME 62 NUMBER 10

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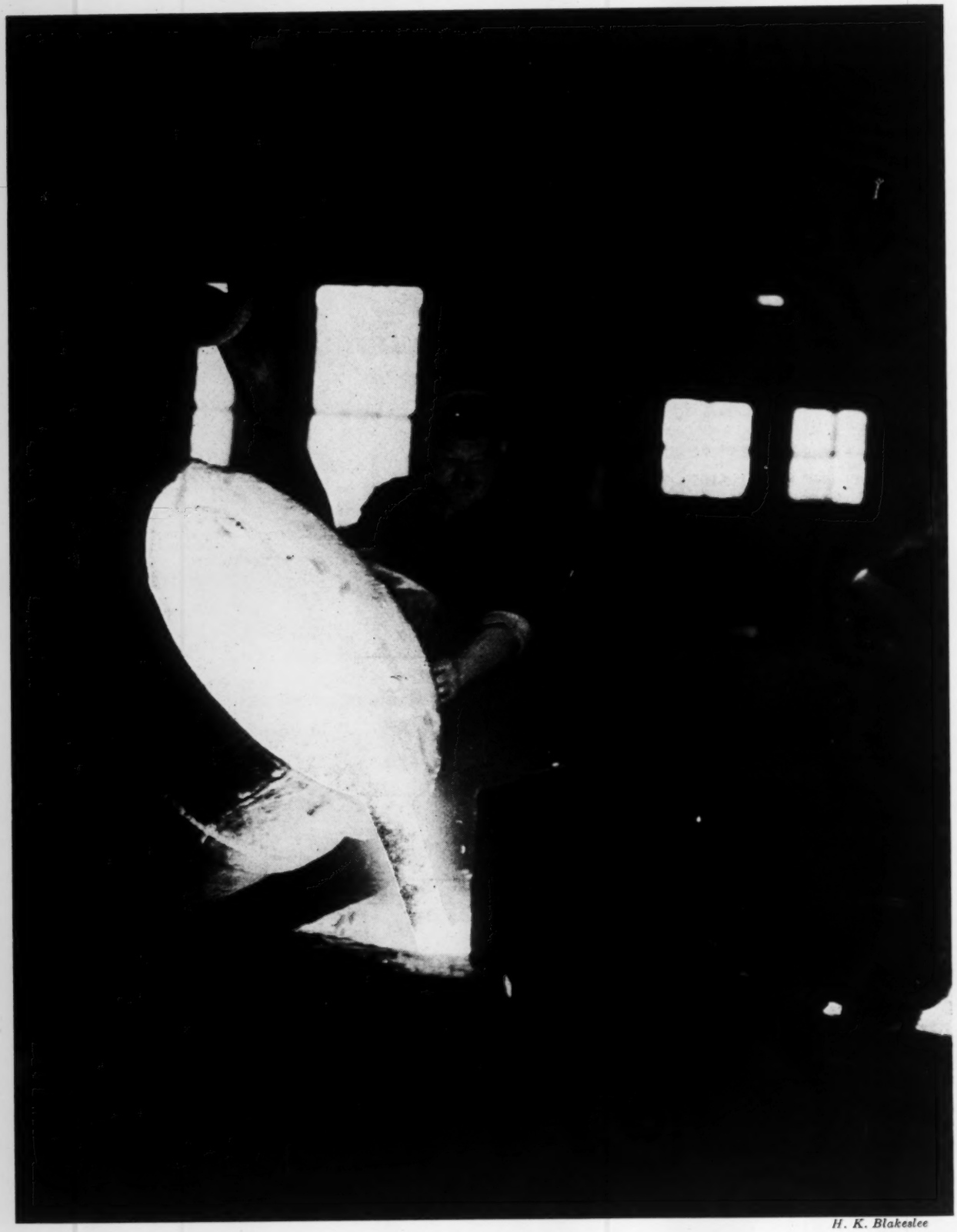

H. K. Blakeslee

"The Bull Ladle"

VOLUME 62
No. 10

MECHANICAL ENGINEERING

OCTOBER
1940

GEORGE A. STETSON, *Editor*

A.S.M.E. Student Members

THIS is the first issue of MECHANICAL ENGINEERING that several hundred new A.S.M.E. Student Members will receive. It is therefore an introduction to them of one of the Society's monthly periodicals, the means by which 14,000 mechanical engineers keep up to date on engineering developments and A.S.M.E. affairs. It is hoped that with the reading of this issue a profitable lifelong habit will be formed by many students.

A.S.M.E. Ammunition Group

AT A meeting of the Executive Committee of The American Society of Mechanical Engineers held in Washington, D. C., on September 15, approval was voted of plans to organize, under the auspices of the Committee on National Defense and the Machine Shop Practice and Metals Engineering Divisions, an Ammunition Group.

The organization of the Ammunition Group is a direct outgrowth of the successful meeting on shell manufacture, held in Pittsburgh, Pa., on September 11 under the auspices of these two divisions and the A.S.M.E. Pittsburgh Section, a report of which will be found on pages 762–764 of this issue.

It was clearly demonstrated at the Pittsburgh meeting that the Society has an opportunity and an obligation to assist, through such forums and in any other ways within the competence of the engineers and industrialists who make up its membership, in the national-defense effort, particularly as it relates to the mechanical problems of ammunition manufacture. In organizing the Ammunition Group the Society is providing a continuing organization that will act as a clearing house of information urgently needed by the scores of plants that will assist in producing ammunition for the Army and Navy Departments in the national-defense effort.

The A.S.M.E. Committee on National Defense, recently enlarged, has provided a continuing point of contact between the Society and the Army and Navy Departments ever since by introducing speakers on national-defense subjects at Society Meetings and by carrying on such other duties and functions as occasion has demanded. The farsightedness of the policy under which this committee was originally organized and has since been maintained has been eminently justified in the light of present events. The Committee was prepared to swing into action early this summer without delay, and one result of that readiness to serve was the meeting on shell manufacture held in Pittsburgh.

Another and larger meeting, announced elsewhere in this issue, will be held in Cincinnati on October 16 and 17. In the interval between the Pittsburgh and Cincinnati meetings the Committee on National Defense met with representatives of the War and Navy Departments in Washington on September 16, at which time the formation of the Ammunition Group was announced and the Committee learned at first hand the needs the Society can meet in this field. As further needs and opportunities for service in the national defense arise, the Committee, which assembles frequently in Washington and has the confidence of Army and Navy officials, will formulate plans to meet them.

The Society is fortunate in having this loyal and competent group of members to represent it in the rapidly developing national-defense effort.

National Roster of Engineers

MEMBERS of The American Society of Mechanical Engineers above the grade of junior will soon receive, from the Roster of Scientific and Specialized Personnel, questionnaires which when properly filled out and returned to Washington will provide means by which the services of specialists can be quickly solicited in the cause of national defense. Junior members will also receive questionnaires sometime before Christmas it is hoped.

The Society has contributed to this project to the extent of assisting in the preparation of a check list of specialties, one of the forms to be made out, and providing the names and addresses of its members. A dozen or more other engineering societies are cooperating in the Roster. Hence, in cases where members belong to more than one society, more than one set of questionnaires may be received. The task of eliminating this duplication before the questionnaires are sent out would delay and complicate the initial steps of building up the Roster.

When the questionnaires are received in Washington, the information they contain will be coded and transferred to punch cards. In making use of the Roster to locate a specialist possessing the qualifications needed for some specific service, a sorting machine will be used to throw out the cards of the qualified men. The questionnaires returned by these men will then be studied and a selection made from them for reference to an evaluation committee, for it is admitted that a machine, unassisted by human

judgment, cannot make an intelligent final choice. The evaluation committee is made up of the secretaries and presidents of the professional societies whose members are in the register. For example, if the names to be considered are those of A.S.M.E. members, Mr. Davies will be called upon to provide, through such facilities as the Society may possess in its records and in the men familiar with the field of service in question, the final list of specialists for the particular service in question.

The National Roster of Scientific and Specialized Personnel "is a project of the United States Government planned to make available in one central office an index of all American citizens who have special scientific or professional skills which may be of importance to the nation in periods of emergency and in normal times." It is a joint project of the National Resources Planning Board and the Civil Service Commission. James C. O'Brien, an executive of the Civil Service Commission, is executive officer of the Roster and Dr. J. T. Nicholas has been appointed by Ross G. Harrison, of the National Research Council, to supervise the registration of members of the engineering societies that are associated with the Council.

Growing Importance of English

A QUARTER of a century's experiences in the reading of manuscripts of engineering papers affords evidence of improvement in the ability of engineers as writers. There are many reasons for this improvement. Today a majority of engineers have been trained in colleges and technical schools. Engineering itself has developed to a point where the contributions to its advance are based largely upon methods and knowledge that the untrained practical mechanic type of engineer seldom possesses. The demand for technical articles and books has greatly increased. Industrial laboratories and publicity departments have insisted on better reports and technical papers to safeguard company prestige and in many cases have undertaken to assist or supervise the preparation of manuscripts that are offered for publication. Engineering societies and technical magazines afforded an increasing number of opportunities for engineers to write and present papers and have attempted to raise standards of quality in their publications. A growing proportion of engineers have discovered that personal reputations may be based on and enhanced by publication; something the scientists learned many years ago. And in educating a vastly greater number of men, the schools, encouraged by men in practice, have been paying more attention to the teaching of English.

With its customary initiative in subjecting the profession it represents to constructive analysis the Society for the Promotion of Engineering Education, through its Committee on English and aided by a grant of $2500 from the Carnegie Foundation for the Advancement of Teaching, undertook early in 1937 a study of the instruction of English in engineering colleges. The report of the committee was published by S.P.E.E. in June, 1940. The substance of the report, says H. P. Hammond, dean of the School of Engineering, The Pennsylvania State College, is embodied in seven chapters dealing with "the function of the department of English in the School of Engineering; the teaching of composition, literature, and speech; the selection and training of teachers; the organization of the English department and conditions surrounding its work; and variants on methods commonly employed in English instruction." Each chapter summarizes facts and opinions.

Dean Hammond presents the committee's general conclusions in the following terms:

> In concluding this report our committee would affirm as a basic conception of work in English, whether for engineers or for other groups, that the portion of the experience of the individual in his effort to achieve requisite ability in the art of expression which is encompassed by the period of study in college, is but one part—a very important one, it is true—of his total program of development. And it should be so considered and evaluated. The college portion of this program begins at a level determined by home and community backgrounds and by previous schooling. Starting from this level it leads the student to some more or less advanced stage of his development. If it is properly conceived and executed, it relates that stage to his immediate future and to his more remote future as well, to the vocational field he will enter, and to the position in society at large that he will achieve, neglecting no one of these aims at the expense of the others. Of basic importance, his period of college training in English should motivate him to continued study and development, not only in the arts of written and oral expression but also in other fields of cultural interest that are related to the study and use of the mother tongue. He should be given such a view of all that is preserved in the writings of our greatest creative minds that he will have the incentive to explore them for himself and thus to enrich his entire life. Of all the members of the faculty of the engineering school, it is the teacher of English who has the unique opportunity thus to direct the student toward this phase of his future development. It is also, without doubt, his greatest responsibility.

The report of the Committee on English will be of chief interest to educators. To engineers the effect on future generations will be significant because of the benefits that reside in the closer integration of English departments and the engineering departments of engineering schools. To develop what has been a stepchild service department into a force for giving broader meaning and purpose to the individual areas of knowledge an engineering student must acquire is no mean accomplishment, and the English departments are being so developed in many institutions.

It is possible to visualize an ever-increasing measure of service to engineering that men who teach English to engineers can perform. Men of broad knowledge, experience, and understanding who combine the ability to teach English in all its phases with intelligent and sympathetic appreciation of the engineer, his work, and his function in society have it in their power to become the most forceful influence in engineering education. Such men will never be common, but as industrial civilization expands and flourishes, the number will increase. It is the obligation of the schools and the profession to see to it that such men find satisfying and remunerative careers in engineering colleges.

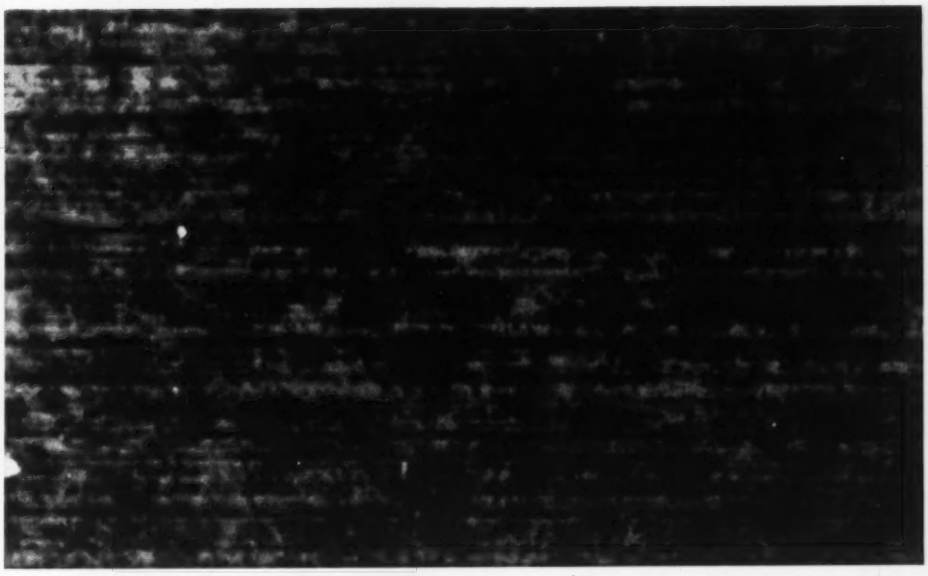

FIG. 1 THRUST-BEARING RUNNER-PLATE SURFACE—CAST IRON

(Magnification ×35. Finished by lapping with parallel concentric finish marks and polished. Light-field illumination. 5 microinches rms roughness.)

HOW SHOULD ENGINEERS DESCRIBE A SURFACE?

By O. R. SCHURIG

GENERAL ENGINEERING LABORATORY, GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

IT IS the purpose of this paper:

(1) To show illustrations of some of the types of surfaces in which we are interested at the General Electric Company, to point out some of their characteristics, and to review the requirements they have to meet.

(2) To submit to the conference questions for the purpose of establishing what surface characteristics need to be considered as a basis for describing and specifying surface deviations in industry. It is hoped that consideration by the conference of the questions presented here will indicate in what surface qualities engineers are interested for all kinds of different surfaces. From this can then be determined whether the proposed ASA standard for roughness[1] is adequate, and what quantities ought to be measured on surfaces of different kinds.

The scope of this paper is limited to a consideration of three kinds of surface deviations or irregularities, namely, waviness, roughness, and flaws which have been defined as follows in the proposed ASA standard on surface roughness:

Waviness. A kind of surface deviation which consists of recurrent or random irregularities in a surface which have the form of waves. On "smooth machined" surfaces, the length of such waves ordinarily is between 0.04 in. and 1.0 in., and the height of the waves is generally not more than a few thousandths of an inch. Such irregularities can be measured by conventional dial gages of appropriate sensitivity, with spherical work contacts of approximately 0.125 in. diameter.

Roughness. Recurrent or random irregularities in a surface which have the form of small waves or bumps. Roughness may be considered as being superimposed upon a nominal surface or upon a wavy surface. On "smooth machined" surfaces, the distance between the "high spots" of such irregularities is ordinarily between 0.0002 in. and 0.010 in., and their height is very much less than their width, usually being between 0.000001 in. and 0.0005 in. Similar dimensions for the irregularities in surfaces which are coarser or rougher than those generally classified as "smooth machined" will be proportionately larger.

Surface Flaws. Irregularities of any sort which occur at only one place or at relatively infrequent and widely varying random intervals in a surface. A surface flaw may be a scratch, a ridge, a hole, or a peak, a crack, a check, etc.

The proposed standard in question provides for expressing surface roughness numerically as the root-mean-square average of the ordinates of a surface profile with respect to its center line. Moreover, the standard provides a definite classification and a set of symbols for various gradations of roughness over a wide range, based on the root-mean-square value.

We do not have a national standard covering the description and designation of surface waviness or of surface flaws.

The following review of surfaces of various manufactured parts includes: (1) Bearing surfaces operated with oil; (2) dry

[1] A Proposed American Standard on "Surface Roughness" was developed by the Sectional Committee on Classification and Designation of Surface Qualities (B46) under the auspices and procedure of the American Standards Association and was issued for a trial period not to exceed two years. It was published March, 1940, by the A.S.M.E., 29 West 39th Street, New York, N. Y.

Presented at a Conference on Friction and Surface Finish at the Massachusetts Institute of Technology, Cambridge, Mass., June 5–7, 1940.

rubbing surfaces; and (3) stationary contact surfaces and joints.

REVIEW OF THE SURFACES OF A NUMBER OF MANUFACTURED PARTS AND THE REQUIREMENTS THEY HAVE TO MEET

1 BEARING SURFACES OPERATED WITH OIL

(*a*) *Thrust-Bearing Runner-Plate Surfaces.* Thrust bearings such as used on vertical-shaft hydroelectric generators consist of a flat, smooth runner plate of chilled cast iron which runs on babbitted bearing shoes immersed in a bath of oil. Fig. 1 shows a photomicrograph of the runner-plate surface (magnification ×35).

Finish: Lapped with parallel concentric finish marks and polished. Visual inspection for surface roughness and flaws. No regular tests for operating performance are made. Reduction of waviness to prevent scoring is of utmost importance.

Waviness measurements: 25 microinches maximum flatness deviation (total height) measured with an electric limit gage having a contact-shoe area of $^1/_2 \times 4$ in.

Straightedge test across diameter to hold maximum deviation to less than 0.5 mil.

Roughness measurements on a surface of this type: 5 microinches root mean square by profilometer.

Unit pressure (nominal): 400 psi.

The surface shown in Fig. 1 has surface finish marks parallel to the direction of motion.

Tests were made comparing starting friction for runner plates finished by somewhat different processes.

The starting-friction tests were of two kinds: (1) By measurement of the horizontal force required to start motion of the bearing when loaded vertically in an Olsen loading machine (see Fig. 2 for test setup); (2) by measurement of starting torque, electrically, of the bearings in a complete vertical

FIG. 2 CAST-IRON THRUST BEARING AND BABBITTED SHOE SETUP FOR STARTING-FRICTION TESTS IN LOADING MACHINE

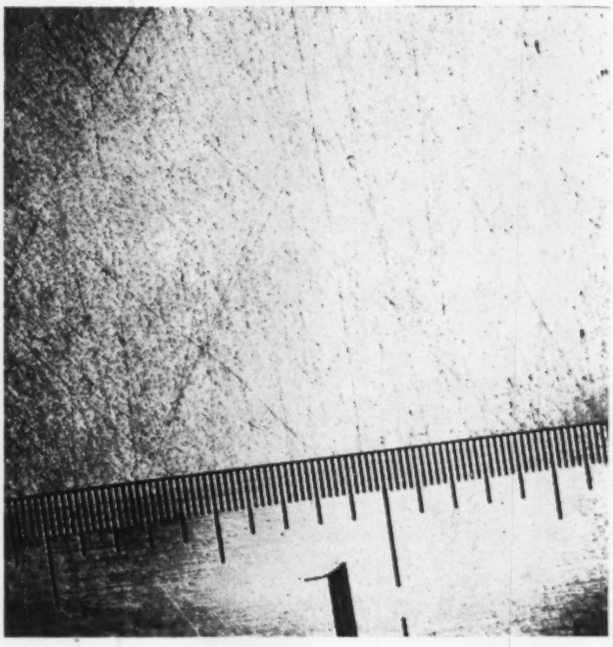

FIG. 3 THRUST-BEARING RUNNER-PLATE SURFACE—CAST IRON (Random finish marks. Smallest divisions on scale = 0.01 in. Magnification ×3.5. Light-field illumination.)

machine assembly to which was coupled in each case a direct-current starting motor for torque measurement by electrical input.

For the surfaces tested, see Figs. 3 and 4 for surfaces with random finish marks and Fig. 5 for the same plate after refinishing with concentric finish marks (magnification ×3.5).

The tests in the Olsen loading machine (Fig. 2) gave the following results:

Surface	Coefficient of starting friction, i.e., ratio of horizontal pull to start, to vertical load	Condition	Load range, lb
With random finish marks, Figs. 3 and 4	0.42–0.52	Surface *dry* after cleaning with CCl_4	2000 to 6000
Surface with parallel finish marks, Fig. 5	0.26–0.28	Same	Same

These results were roughly checked in the electrical starting-torque tests on the same bearing surfaces.

No measure of surface roughness was obtained on the samples tested for starting friction, so that differences of roughness magnitude as well as differences in the direction of the finish marks along the surface may have contributed to the magnitude of the starting friction. The test served to select the better of the methods of finishing, i.e., the one with parallel concentric finish marks, for the bearing runner plates. The tests suggest at least the possibility of the direction (along the surface) of the scratches having an effect on the performance of the bearing surface.

It is concluded that for these surfaces reduction of waviness and parallel finish marks in the direction of motion are important. The two following questions are therefore brought to the attention of the conference: (1) Whether other studies have confirmed a relationship between direction of finish marks and starting friction. Possibly a rough surface with marks parallel

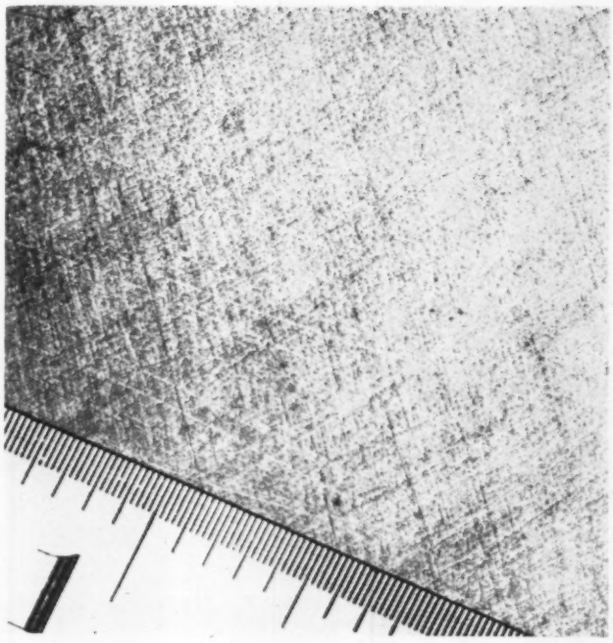

FIG. 4 THRUST-BEARING RUNNER-PLATE SURFACE—CAST IRON; THE SAME PLATE AS THAT SHOWN IN FIG. 3, AFTER REFINISHING BY HAND-STONING

(Random finish marks. Smallest division on scale = 0.01 in. Magnification ×3.5. Light-field illumination.)

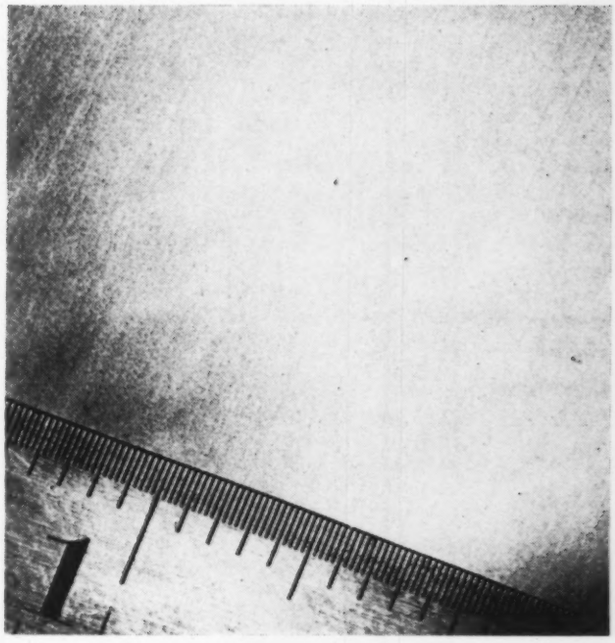

FIG. 5 THRUST-BEARING RUNNER-PLATE SURFACE—CAST IRON

(Parallel concentric finish marks. Smallest division on scale = 0.01 in. Magnification ×3.5. Light-field illumination.)

to the direction of motion may be as useful as a smoother one with random marks. (2) In view of the importance of waviness, should not a standard be provided for describing waviness?

(*b*) *Oil-Pump Bore for Refrigeration Machine.* Another rubbing surface is that of the bore (Fig. 6) of a small oil pump used in a refrigerating machine. Small pump blades slide on the surface of the bore.

Finish: Honed and polished with substantially concentric finish marks, parallel to direction of sliding.

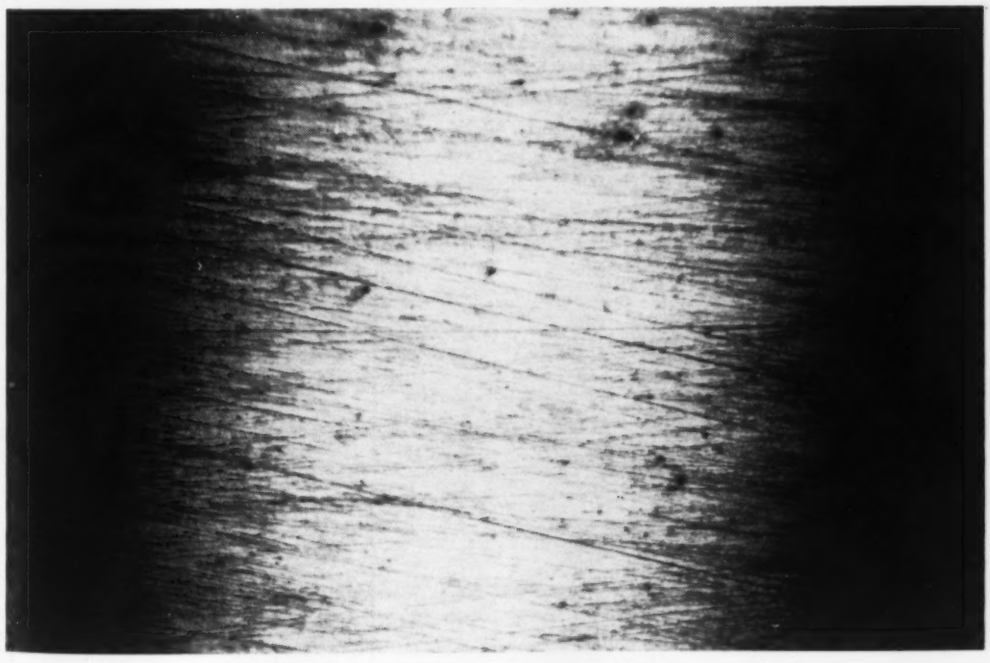

FIG. 6 SURFACE OF OIL-PUMP CYLINDER BORE

(Magnification ×50. Honed and polished surface. Light-field illumination. Roughness, 1.5 microinches rms.)

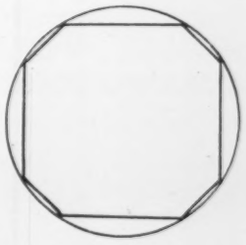

FIG. 7 ARBOR FOR TESTING DIMENSION AND SURFACE DEVIATIONS OF CYLINDER FOR OIL PUMP

The production test for waviness, roughness, and surface projections is illustrated in Fig. 7, which shows a very slightly tapered rectangular arbor, with its edges trimmed off, over which the cylinder $\frac{1}{4}$ in. long is rotated by hand to detect objectionable departures from the true surface.

In addition to the foregoing test, each piece is given a visual inspection.

Roughness measurements are not regularly made. One sample measured 1.5 microinches root-mean-square roughness[2] in an axial direction.

[2] Roughness measurements reported in this paper were all obtained by profilometer.

The chief requirement for this surface is freedom from chattering due to surface irregularities encountered in the direction of motion, i.e., peripherally; freedom from *projections above the surface* met in direction of motion is particularly important, whether due to roughness, waviness, or nicks of any kind.

An earlier design of the same piece several years ago was finished by grinding and honing, but was noisy owing to chattering and gave rapid wear.

These observations indicate that, in surface finish designations of roughness and of waviness, a distinction between projections above and depressions below the prevailing surface contour may be needed. The question is therefore put before the conference as to whether the description of a surface should not take into account the direction of irregularities above or below the surface, as a significant factor in surface quality.

Attention is called to the fact that this is an example of a very smooth surface manufactured by high-speed production methods, which has been used in large quantities for more than five years in electrical manufacturing. It is also noteworthy that each piece is carefully tested in a simple production test to determine its fitness for the exacting job it has to perform in a refrigerator oil pump.

(*c*) *Thrust-Bearing Plate for Crankshaft for Refrigeration Machine.* Another example of a bearing surface operating with oil is the thrust-bearing plate shown in Fig. 8 at a magnification of 50. Descriptive data and characteristics are as follows:

Case-hardened steel ground surface finished by honing.

Chief operating requirement: Must operate without objectionable noise and wear as a load-bearing surface at 1750 rpm, crankshaft speed.

No production test, but visual inspection of each sample is made. Experience has shown that with accurate control of manufacturing operations no tests are needed for waviness and roughness, though reduction of both is important.

Roughness measurement on occasional samples: 2 to 3 microinches root mean square.

A grinding finish was previously used, but operation was noisy and gave indications of wear.

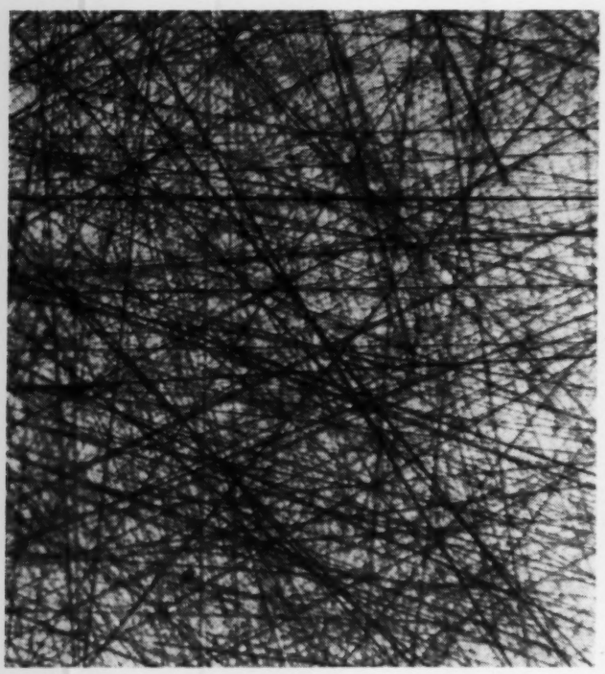

FIG. 8 SURFACE OF THRUST-BEARING PLATE FOR CRANKSHAFT FOR REFRIGERATION MACHINE

(Case-hardened steel ground and honed. Magnification ×50. Light-field illumination. Roughness, 2 to 3 microinches rms.)

FIG. 9 THREE DRILL-ROD JOURNALS, EACH 1/4 IN. DIAM, TESTED FOR SEIZURE UNDER LOAD

[Magnification ×10.5. Lower sample: Finished by grinding and polishing; roughness, 18 microinches on original surface (left). Middle sample: Finished by grit-blasting; roughness, 60 microinches on original surface (left). Upper sample: Finished by sand-blasting; roughness, 60 microinches on original surface (left).]

The surface shows a random pattern of finish marks which is not objectionable considering the smoothness of the surface and the fact that starting torque is not important.

This is another example of a surface with a very smooth finish which has been produced and successfully used in large quantities over a period of more than five years.

Since the chief function of all bearing surfaces is to carry a load without scoring or other forms of wear or noise, the question arises whether the available contact area per unit nominal area is not a measure of surface quality. R. J. Walker[3] has suggested a designation including a figure expressing in percentage the amount of bearing surface in relation to the whole surface, though no evidence is given to point out quantitatively its significance in the usefulness of a surface.

(*d*) *Sandblasted Vs. Ground Surfaces for Journal Bearings.* In connection with the discussion of bearing surfaces an interesting preliminary series of tests was run, comparing a ground and polished drill-rod journal 1/4 in. diameter with similar journals having surfaces finished by sand-blasting and by grit-blasting. The rods were operated against ground, cold-rolled steel bushings by the use of an Almen film-strength testing machine to determine the load-carrying capacity up to the breakdown point of the oil film.

Fig. 9 shows the surface condition of the three journals, illustrating both the original surfaces and the surfaces after operation. The results of the tests were as follows:

Surface finish	Rms roughness, microinches on original surface	Max load, psi
Ground and polished	18	8500[a] (seizure took place)
Sandblasted	60	24000 (no seizure)
Grit-blasted	60	28900 (no seizure)

[a] Average of two tests; seizure occurred in both tests at 8440 and 8570 psi.

Fig. 10 shows plan-view photomicrographs and surface profiles by light-slit method[4] for

(*a*) Ground surface (original) of a plane surface which measured 16 microinches root-mean-square roughness. This is not the surface of the 1/4-in. shaft used in the seizure test, but the surface of a flat piece finished by grinding and having substantially the same root-mean-square roughness as that of the shaft tested.

(*b*) Sandblasted surface (original), of 1/4-in. shaft, 60 microinches.

In the two lower illustrations, the boundary line along the bottom of the lighted area shows the surface profile. The ground surface in these illustrations shows the rather jagged irregularities of relatively short wave length, while the sandblasted surface is characterized by a profile of larger wave length with relatively wide cavities and pockets.

While exhaustive tests on the relative merits of the two surfaces in question, for bearings, have not yet been made, the following tentative conclusion is indicated: That the sandblasted surface and the grit-blasted surface, though rougher, appear to have an advantage over the smoother ground surface having materially different profile shape, in respect to load-carrying ability in a bearing, but would not be expected to show any reduction of losses under normal running conditions. Shaw[5] also suggested that a smooth surface is not always better than a rougher one and based this conclusion on load-carrying tests of metal-sprayed steel shafts having a porous surface compared with hardened steel shafts. Furthermore, Wulff[6] pointed out that it is possible for surfaces of the same material, finished by different methods, but all measuring two microinches root-mean-square roughness, to behave differently in respect to strength, friction, corrosion, and erosion. Whether this is due to the shape of the surface alone or to the characteristics of the metal below the surface we do not know.

The foregoing observations suggest these questions to be submitted to the conference: What physical characteristics of a bearing surface determine its ability to carry loads, and is the root-mean-square value of surface deviations an adequate measure of surface quality?

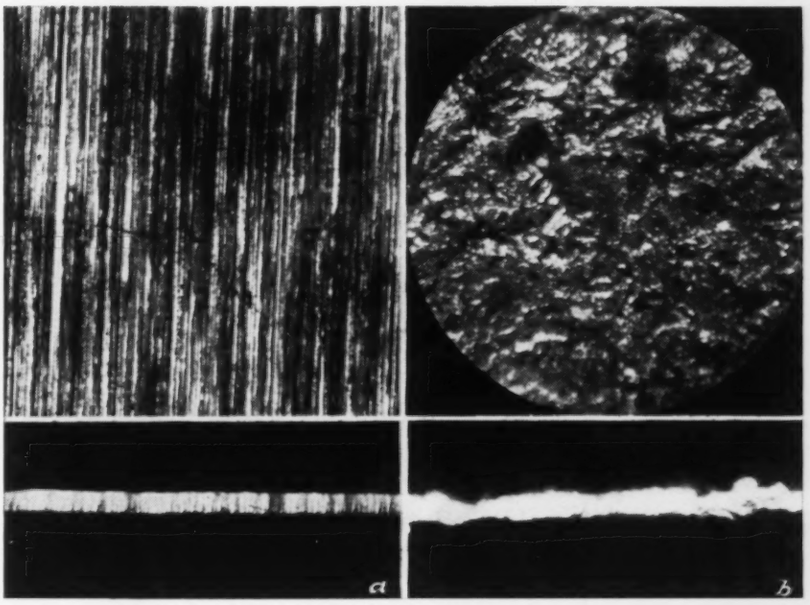

FIG. 10 PLAN-VIEW PHOTOMICROGRAPHS (UPPER ILLUSTRATIONS) AND SURFACE PROFILES (LOWER ILLUSTRATIONS) BY LIGHT-SECTION METHOD (ZEISS FINISH-GAGING MICROSCOPE) [(*a*) Ground surface (plane), 16 microinches rms. (*b*) Sand-blasted surface (original) of 1/4 in. shaft shown in Fig. 9, 60 microinches rms.]

2 RUBBING SURFACES—DRY—COLLECTOR SURFACE

Fig. 11 shows a surface of collector rings of forged steel such as used on high-speed turbogenerator rotors. There are grooves between adjacent contact rings. The principal information pertaining to this surface is as follows:

Finish obtained by turning and lapping.

Chief requirement: To operate as a sliding contact for graphite brushes at a specified current density. The condition of the surface limits the speed, pressure, and current at which the contact will operate satisfactorily.

The suitability of the surface is determined by visual appearance and

[3] "Designation of Surface Qualities," by Robert J. Walker, *Product Engineering*, Aug., 1935, pp. 289–291.

[4] By Zeiss finish-gaging microscope employing the light-section method.

[5] "Metal Sprayed Surfaces in Relation to Lubrication," by Harry Shaw, a paper presented at Manchester, Oct. 20, 1937, and reprinted by Metallizing Engineering Co., Inc., 21-07—41st Ave., Long Island City, N. Y.

[6] "Friction, Fuzz, and Hair Oil," by John Wulff, *Technology Review*, May, 1940, pp. 282–284; 296–298.

FIG. 11 SURFACE OF FORGED-STEEL COLLECTOR RINGS FOR TURBOGENERATOR ROTOR

[Dark areas are grooves between the contact rings. Magnification ×2. Collector surfaces (lighter areas) finished by turning and lapping with parallel concentric finish marks.]

by temperature rise of the brushes when carrying current after the wearing-in operation. Absence of chatter is required. Waviness requirements are satisfied by control of finishing operations and by results of run-in test.

No surface-finish measurements have been made.

This is an example of a surface for which smoothness in the direction of motion along the surface is greater than that in a direction at right angles to the motion. The limits of permissible waviness or the roughness characteristics most suitable for collector-ring operation have not been determined. The question is therefore asked: What surface characteristics are pertinent for dry rubbing surfaces?

3 STATIONARY CONTACT SURFACES AND JOINTS

(*a*) *Exhaust-Valve Disk.* Fig. 12 shows the surface of the rim of the exhaust-valve disk at a magnification of 100, used in a refrigerating machine. The data of interest pertaining to this surface are the following:

Material: Swedish steel sheet.

Rim of disk finished by lapping.

Chief operating requirement is that it must not leak gas when the disk rim is held against the valve plate.

Production test on each sample: After assembling with valve plate, test for air leakage is made at 175 psi air pressure with an air gage using a U tube with a column of liquid to indicate leakage.

While some scratches are visible along the face of the contact, a high standard of flatness and freedom from scratches deep enough to allow gas leaks are required. This surface will be further considered together with the valve plate, the surface of which is shown in Fig. 13.

(*b*) *Valve Plate for Refrigeration Machine.* The surface of Fig. 13, at a magnification of 100, is that of a case-hardened steel plate finished by grinding and honing. The data and performance requirements for this surface are the following:

Principal requirement: No gas leaks between plate and valve disk (Fig. 12).

Production test: Air-gage test described in connection with Fig. 12, the valve disk.

No surface roughness measurements made regularly. Tests on a few samples gave roughness measurements of 4 microinches root mean square.

Other finish considered: Grinding without honing. Objectionable leakage occurred.

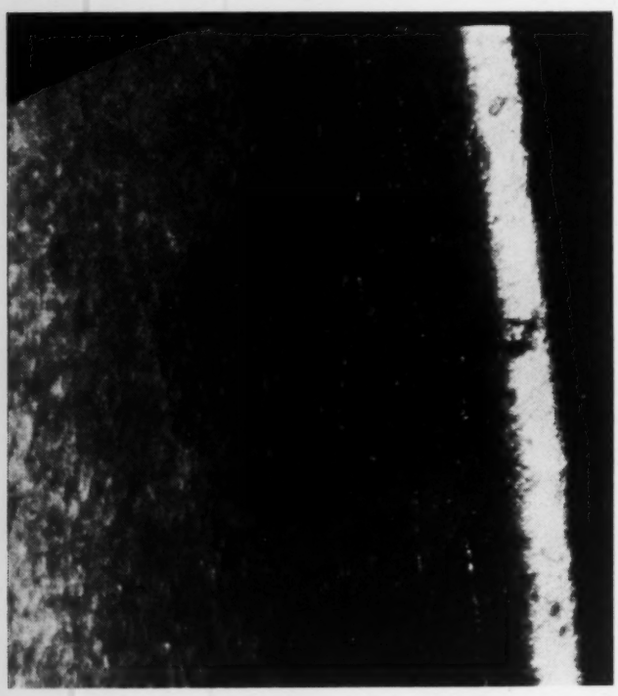

FIG. 12 RIM OF EXHAUST-VALVE DISK

(Magnification ×100. Swedish steel sheet finished by lapping. Light-field illumination.)

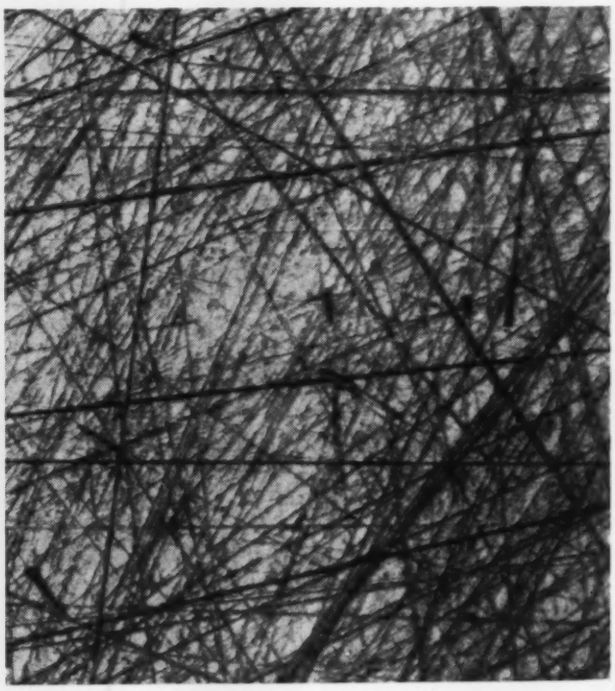

FIG. 13 SURFACE OF VALVE PLATE FOR REFRIGERATION MACHINE

(Magnification ×100. Case-hardened steel plate finished by grinding and honing. 4 microinches rms roughness. Light-field illumination.)

Here again the requirements appear to be small waviness, small depth, and width of depressions and scratches. Furthermore, a minor projection would apparently be far more serious than a depression of similar proportions. To specify all of these requirements numerically would require something more than the root-mean-square height of the surface profile measured with respect to the center line. Schmaltz,[7] for example, has suggested the use of a form factor in addition to a height value for the descriptions of surface deviations, the form factor he recommends being the ratio of average height to maximum height above the base line (see Fig. 19). The question is therefore asked: What are the major characteristics of a surface that determine its ability to prevent gas leakage in a joint under pressure?

(*c*) *Scraped Surface for High-Pressure Steam Joint.* Fig. 14 shows the plan view of a surface of cast steel finished by planing and hand-scraping, such as used for steam joints of high-pressure turbine shells (2.5 magnification). The principal data for this surface and for its application are the following:

The chief operating requirement is that it must hold steam pressure. For the case shown, the operating pressure is 400 psi at 900 F. During scraping, the surface is tested by surface plate for high points.

No surface-finish measurements are regularly made. The particular samples shown in Fig. 14 measured 200 microinches waviness, maximum value from crest to valley, with electric limit gage. A roughness measurement by profilometer gave 30 microinches root mean square on a small surface finished by the same process.

The illustration clearly shows the crisscross pattern of finish marks typical of a scraped surface.

Evidently a joint having surfaces 100 per cent in contact would be ideal for this purpose, so that a designation of the percentage of contact area with a perfect mating surface would indicate the degree of approach of any one surface to the ideal. Would not the percentage of contact area be a suitable criterion for the quality of a contact surface?

[7] "Technische Oberflachenkunde," by Gustav Schmaltz, Julius Springer, Berlin, 1936, pp. 116–117.

FIG. 14 SCRAPED SURFACE FOR CAST-STEEL HIGH-PRESSURE STEAM JOINT

(Finished by planing and hand-scraping. Magnification ×2.5. 200 microinches waviness, maximum value from crest to valley. 30 microinches rms roughness. Light-field illumination.)

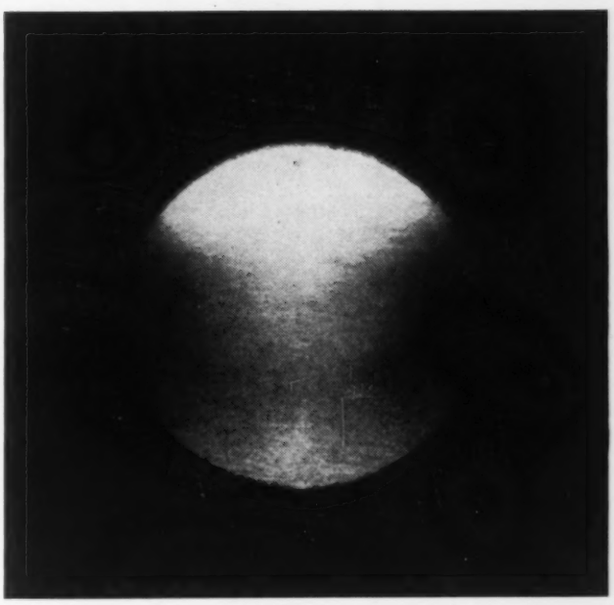

FIG. 15 CONTACT SURFACE OF 2 × 1/4-IN. FLAT ROLLED-COPPER BAR AFTER IT HAD BEEN ASSEMBLED AND BOLTED TO ANOTHER BAR

(Finish: Ground on disk sander with parallel finish marks; the finish marks for the two mating surfaces were at right angles to each other, giving the crossed pattern of multiple contact points. Diameter of hole, 21/32 in.)

(*d*) *Contact Surface of an Electrical Joint.* Another form of contact surface is that used for bolted joints of electric bar conductors. The surface shown in Fig. 15 is that of a 2 × 1/4-in. flat rolled-copper bar after it had been assembled with and bolted to another bar.

Finish: Ground on disk sander with parallel finish marks. The finish marks in the two mating surfaces were at right angles to each other.

Tests: No regular tests of surface finish are made, experience having indicated this to be a satisfactory surface obtainable by a simple procedure from standard stock.

Roughness: 100 root-mean-square microinches by profilometer on a similar sample after grinding before assembly.

The deformation of the ridges on one surface by those on the other under the pressure applied resulted in a multiplicity of contact points shown. Should not therefore the uniformity and the wave length of the surface irregularities be considered as a basis for describing this type of contact surface?

In this connection, let us turn to Fig. 16 which shows four sample blocks having the same over-all root-mean-square roughness of 130, approximately.

SURFACES HAVING THE SAME OVER-ALL RMS ROUGHNESS

In this figure are shown surfaces finished by (1) shaper machining, 150 microinches; (2) grinding, 130 microinches; (3) milling, 135 microinches;[8] (4) profiling (end milling), 130 microinches, all root-mean-square over-all roughness measurements taken crosswise to the highest waves.

The grinding finish shown here is slightly rougher (130 microinches) than that applied to the copper bar just mentioned (100 microinches). It is evident that the four surfaces, all obtained by methods in common use, are far from identical in appearance and surface quality. It is also evident that contact surfaces of different character from the one previously

[8] Determined by electric limit gage, in the direction of feed.

FIG. 16 SURFACES OF FOUR SAMPLE BLOCKS OF 18-8 CHROME NICKEL STEEL HAVING THE SAME ORDER OF MAGNITUDE OF OVER-ALL RMS ROUGHNESS

(*a*) Shaper machining...150 microinches rms over-all roughness.
(*b*) Grinding.....130 microinches rms over-all roughness.
(*c*) Milling.....135 microinches rms over-all roughness.
Determined by electric limit gage in the direction of feed.
(*d*) Profiling (end milling)...130 microinches rms over-all roughness.
[All measurements taken crosswise to the highest waves.]

shown (Fig. 15) would be obtained with surfaces prepared by shaper machining, milling, or profiling.

Obviously, the root-mean-square designation alone (measured with respect to the center line of the profile) will not distinguish between the four surfaces.

What other designation in addition to the root-mean-square value, or in place of the root-mean-square value, shall be used to distinguish between surfaces of this kind?

It has been suggested by others that the root-mean-square designation be qualified by reference to the process used in finishing. This sort of qualification would of course not be necessary if we really knew how to describe a surface, i.e., if we really knew what surface deviations we are interested in. Moreover, reference to the finishing process will not give a quantitative description of surface deviations unless the numerous variables of the finishing process itself are clearly defined.

SURFACES FOR OTHER APPLICATIONS

A similar review of surface finish requirements could be made for surfaces used in a number of other applications. A series of corresponding questions could also be asked inquiring about the surface qualities important in their use. Only brief mention will be made of the effect of surface finish on fatigue failure as applied to members subjected to repeated stresses. Various studies[9] have shown that the fatigue limit of a member is materially affected by the finishing process it has received, the fatigue strength diminishing with increasing depth of finish marks, or of individual scratches. It is also pretty well established that the curvature at the base of the scratch is a factor in the fatigue strength. Should not, for these reasons also, a designation of surface quality enable one to distinguish between scratches and projections and provide for a more complete description than that indicated by the root-mean-square height of the profile curve measured from its center line?

Among the many other functions and properties of a surface which are affected by its shape are the following: heat transfer by fluid flow (forced convection), heat conduction by direct contact, flow resistance, evaporation of liquids, condensation of vapors, luster, appearance, corrosion, and erosion.

These properties will likewise need to be considered in determining what qualities of a surface are important and how they should be described.

SURFACE IMAGES OBTAINED WITH THE AID OF SMALL CONCENTRATED LIGHT SOURCE

In connection with the consideration of surface waviness, the illustrations shown in Figs. 17 and 18 will be of interest. They represent images of highly polished surfaces reflected on a

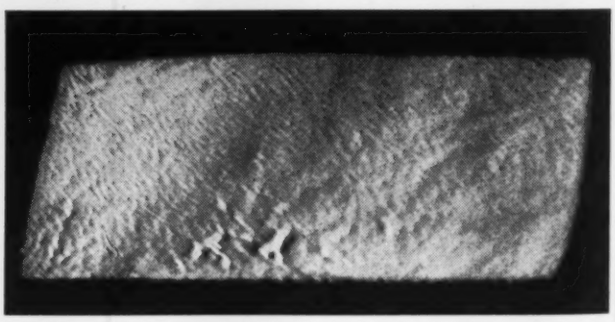

FIG. 17 REFLECTED IMAGE OF HIGHLY POLISHED STEEL SURFACE ILLUMINATED FROM A SMALL CONCENTRATED LIGHT SOURCE 1000-WATT, WATER-COOLED, CAPILLARY MERCURY LAMP

(Light and dark waves indicate waviness of surface not seen by visual inspection. The entire 2-in-square surface is shown with one side elongated by reflection angle.)

[9] "The Fatigue of Metals," by H. F. Moore and J. B. Kommers, Engineering Experiment Station, University of Illinois, Urbana, Ill., Bulletin 124, 1921; W. N. Thomas, *Engineering*, Oct. 12, 1923, vol. 116, p. 449. See also list of references pp. 181–183. "Technische Oberflachenkunde," by Gustav Schmaltz, Julius Springer, Berlin, 1936.

white screen and were obtained by illuminating the surfaces by a small concentrated 1000-watt mercury-vapor lamp of the water-cooled capillary type.[10]

Fig. 17 is the image of a polished steel surface, approximately 2 × 2 in. showing deviations from flatness in the light and dark areas and waves in the image. The major deviations were also indicated, in separate observations not shown here, by interference bands using an optical flat.

Fig. 18 in the rectangular image shows the reflected surface of a steel gage block having a very flat, smooth surface. The circular image is that of a highly polished steel surface, approximately 2 in. in diameter, having both minor and major waviness deviations shown by the various light and dark areas.

While these images do not give numerical indications of the magnitude of the deviations, they clearly show, for the entire surface, in the case of flat polished surfaces, the presence of the waviness deviations not observable by ordinary visual inspection. Clear images of waviness by this method are obtained for well-polished surfaces only.

SUMMARY OF QUESTIONS

1 Have other studies shown that surfaces with finish marks parallel to motion have lower starting friction than surfaces with random finish marks?

2 Should not a standard be provided for describing waviness?

3 Should not description of surface take into account the direction of irregularities above or below surface?

4 What physical characteristics of a bearing surface determine its ability to carry loads?

5 Is the root-mean-square value of surface deviations an adequate measure of surface quality?

6 Is the available contact area per unit nominal area a measure of surface quality for bearing surfaces?

7 What major characteristics of a surface are responsible for its ability to prevent gas leakage in a joint under pressure?

8 What surface qualities are pertinent for the best performance of dry rubbing surfaces?

9 Should not uniformity and wave length of surface irregularities be considered in describing contact surfaces?

CONCLUSION

The geometrical characteristics of a surface profile are so numerous that the shape of a surface cannot be adequately described by a single parameter of its profile.

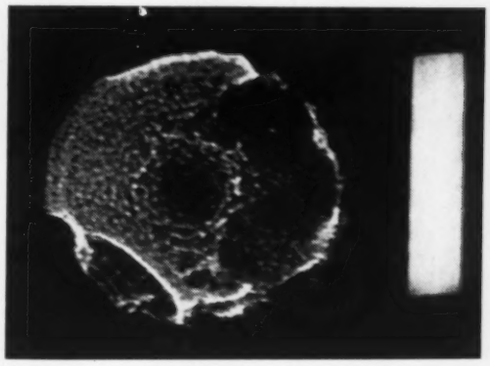

FIG. 18 REFLECTED IMAGE OF TWO HIGHLY POLISHED STEEL SURFACES ILLUMINATED FROM A SMALL CONCENTRATED LIGHT SOURCE, AS IN FIG. 17

[Rectangular piece waviness deviations less than 10 microinches. Circular piece (about 2 in. diam) illustrating waviness deviations by light and dark areas.]

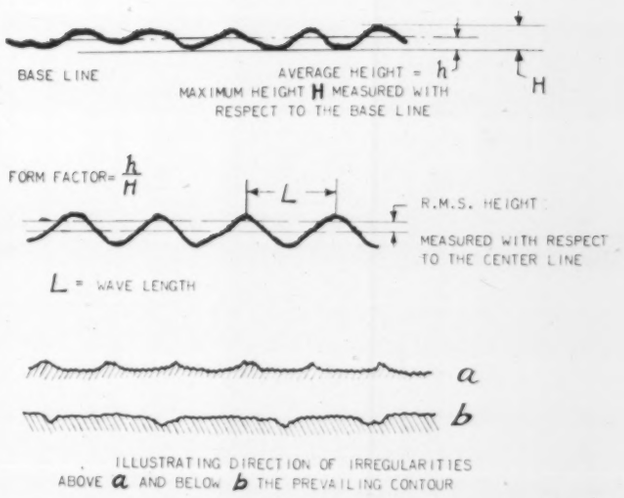
BASE LINE
AVERAGE HEIGHT = h
MAXIMUM HEIGHT H MEASURED WITH RESPECT TO THE BASE LINE
H
FORM FACTOR = h/H
L
R.M.S. HEIGHT
MEASURED WITH RESPECT TO THE CENTER LINE
L = WAVE LENGTH
a
b
ILLUSTRATING DIRECTION OF IRREGULARITIES ABOVE a AND BELOW b THE PREVAILING CONTOUR

FIG. 19 GEOMETRIC CHARACTERISTICS OF SURFACE PROFILES

[Average height h above base line of profile curve. Maximum height H above base line. Form factor $\frac{h}{H}$. Rms average of ordinates of profile curve measured with respect to the center line. Wave length L. Illustrations of surface profiles with the irregularities (a) above and (b) below the prevailing contour.]

The following geometrical characteristics have been suggested or considered in connection with the description of a surface (see Fig. 19):

Maximum height from highest to lowest point.

Average height above base line passing through lowest point.

Form factor, being the ratio of average height to maximum height above base line.

Root-mean-square average height with respect to center line of profile.

Prevailing wave length.

Direction of irregularities above or below the prevailing surface contour.

Direction of finish marks with respect to coordinates of the surface.

Available contact area per unit nominal area.

Efforts should be concentrated to determine what geometrical qualities are important for surfaces used in different kinds of applications and in different industries. Once the significant qualities have been agreed on they should be used as a basis for standards covering the description and designation of surface quality. The standards should provide adequately for describing waviness, roughness, and surface flaws.

A designation of surface qualities including reference to a process of finishing may be useful in giving instructions in the shop, but the purpose of the standard is not to specify how the surface shall be made, but how it shall be described.

The solution of the problem of establishing an adequate basis for specifying the surface characteristics which are significant is not likely to be obtained through the work of one person or of one industry, but requires the combined efforts of a wide group comprising all phases of the problem, namely: Design, manufacture, and preparation of surfaces; application under various operating conditions, including selection and use of lubricants; description and measurement of surface quality.

Acknowledgments are made to Mr. L. M. Nielsen for his assistance in the preparation of the data for the surfaces, and to the staff of the metallography division of the Works Laboratory of the General Electric Company, Schenectady, N. Y., for their cooperation in preparing the illustrations.

[10] See "A Water-Cooled Quartz Mercury Arc," by E. B. Noell and R. E. Farnham, *Journal of the Society of Motion Picture Engineers*, vol. 31, no. 3, Sept., 1938.

The Employer Suggests NEEDED IMPROVEMENTS *in Our System of* TECHNICAL EDUCATION

By W. H. CARRIER

CHAIRMAN OF THE BOARD, CARRIER CORPORATION, SYRACUSE, N. Y.

THE successes and failures of technical education can best be judged by those who have had to deal directly with large numbers of young engineering graduates. All of those whose duty it is to train and supervise these young men and to utilize their abilities in business and in industry may be considered employers. This includes everyone in an engineering or manufacturing organization from the assistant engineer to the president. Employers in higher ranking positions in such organizations have usually come up from the bottom of the engineering ladder and have had the advantage of association not only with the young engineering graduate, but with engineers of more advanced development.

A successful executive must be a good teacher because it is upon the selection and training of men under him that he builds his own success. This experience gives him an opportunity to observe both the good and bad points in technical education in this country and in many foreign countries, since he is frequently associated with engineers of foreign training. This experience also qualifies him to criticize weaknesses in our present system of technical education in this country. For this reason, the employer's viewpoint should carry the utmost weight in the councils of technical educators. While the ideas and opinions set forth in this paper are the result of personal experience, they are far from being individualistic.

Many of the criticisms which can be made in general of present-day technical education obviously do not apply equally to all institutions as there will naturally be found considerable diversity not only in the educational ideals of these institutions, but in the degree of practical application of such ideals. There are many features in our technical education which are commendable from the employer's standpoint. One of these is shop practice in which the student actually learns to do things with his hands. Another is the drill in work habits. Most technical colleges do not fail from the standpoint of giving students plenty of hard work.

There are, however, at least five different features in our present-day technical education which are justly subject to criticism. These, of course, do not apply equally to all institutions, but can be accepted as fair criticism of the average institution. They are as follows: (1) Trend toward specialization in undergraduate courses; (2) lack of proper standards of selection of students to be admitted to engineering courses; (3) failure to develop in the student the habit of thorough understanding of subject matter and processes; (4) insufficient emphasis placed on development of student personality; (5) examinations and student grading which are not the true test of student ability desired by the employer.

It would seem that there is one underlying error common, at least in practice if not in theory, in most of our institutions to which these various faults may be traced. This is the failure to appreciate that the chief objective of a technical education should be to train the student in logical thinking and develop his creative imagination; that it should be aimed primarily toward the acquisition of power rather than toward the amassing of factual knowledge. Many educators will not admit that this is a sound accusation, but while many agree with this statement in theory, they fail to carry it out effectively in practice.

UNDERGRADUATE SPECIALIZATION

The trend toward following the latest educational fad of the day to the injury of sound basic education is a serious problem in all of our engineering colleges. It is the consensus of employers of technical graduates that specialization in an undergraduate course is highly undesirable for the following reasons:

1 It takes valuable time of the students which may be employed in obtaining a more thorough understanding of, and training in, the fundamentals of engineering and their broad, rather than specialized, application.

2 An overcrowded curriculum leads to superficiality rather than thoroughness. Above all things, the engineer must be thorough. It should be the aim of the college to teach thoroughness—and then more thoroughness. The habit of thoroughness, through practice, is one of the traits that the college can most successfully develop in students of all grades of mental capacity. Thoroughness, which includes and emphasizes understanding, should be the first objective of engineering training. According to the experience of employers, if thoroughness is acquired other results of education are relatively unimportant. Factual and specialized knowledge is attained rapidly with opportunity in the graduate's chosen field.

3 With few exceptions, current engineering practice in special fields cannot be taught successfully to undergraduates. The newer arts are advancing with exceeding rapidity and textbooks are out of date almost before they are printed. Such courses can be taught successfully only by specialists who are practicing engineers and, therefore, taught as lecture courses. Otherwise, methods and facts presented are incorrect or out of date, and sometimes the effort expended in such courses by the students is worse than wasted. It will be several years after graduation before he is able to command leadership in his chosen specialized field and here he will have ample time to acquire the specialized knowledge demanded.

4 Probably more than 90 per cent of the students do not follow the field in which they have specialized when at college. Circumstances and opportunity for employment play the most important parts in the ultimate selection. In other words, 90 per cent of the time and effort spent in specialization, except as it may be useful as training in the application of fundamentals and thoroughness, is entirely wasted.

Contributed by the Committee on Education and Training for the Industries and presented at the Semi-Annual Meeting, Milwaukee, Wis., June 17–20, 1940, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

5 Specialization adds unnecessarily to the over-all cost of running a technical college. Cost of instruction in, and operating laboratories for, specialized fields is out of proportion to the cost of the more important fundamental instruction.

That technical employers even in highly specialized fields are solidly opposed to undergraduate specialization is well borne out by the investigation made by Dean Hollister of Cornell University. He recently visited four of the leading aeronautical industrialists to discuss the desirability of introducing at Cornell a curriculum in aeronautics similar to that which has been established in a few technical schools. Somewhat to his surprise, all these industrialists were definitely opposed to the idea of attempting to include such a curriculum in a four-year course. They gave reasons similar to those I have advanced and further backed their opinions by citations from their experiences with engineering graduates. They all preferred a broad engineering education, based on a thorough training in fundamentals during the first four years; if highly specialized training were to be given it should be confined to a postgraduate course in the fifth year.

Personally, I can vouch for the same attitude in the case of myself and associates in the specialized fields of heating, ventilating, and air conditioning. We prefer a thorough and broad grounding in fluid mechanics, thermodynamics, and heat transfer.

INADEQUATE STANDARDS OF ADMISSION

While most deans of engineering will not admit it, there exists nevertheless a subtile yet definite competition among technical schools for either numbers or quality of students. This leads, on one hand, to putting forth undesirable undergraduate curricula as window dressing to attract students, and on the other hand, to the admission of some students who are unqualified for an engineering course. In general insufficient consideration is given to student aptitude, and requirements for admission to the course of the type of ability needed in engineering are inadequate.

It may be assumed that most engineering students have an interest in their work. For example, in mechanical engineering we would expect them to have a natural interest in mechanics and mechanical processes. But more than this is required—they must have natural analytical ability. This is the real criterion of whether they should go to a trade school or take an engineering course in a university. I believe many natural artisans are spoiled by trying to make engineers of them. The essential test, therefore, for entrance in an engineering school should be the candidate's analytical ability and reasoning powers. This ability is necessary if the student is to be successful in his college work and in his profession.

It is unfair to the student to admit him to a course for which he is mentally unfit and then "bust" him out in his freshman year. It is still more unfortunate if he is allowed to finish his course by dint of memory and hard work, only to find, after having spent the money and effort, that these have been wasted. Such indiscriminate admission is equally bad for the engineering school. It lowers its standard of teaching and increases its cost of instruction.

Unfortunately, high-school standings alone cannot be taken as sound criteria of the student's analytical ability. High schools today have problems which did not exist a few years ago. The increase in the age of employment, combined with compulsory education, has put into high schools large numbers who are not interested in further instruction, as well as many who do not have the ability for high-school work. This necessarily lowers the standards in many high schools and tends to mechanize secondary education. Entrance requirements must be revised to take into consideration definitely poorer standards of secondary education. This means that the candidates should be qualified for entrance into engineering courses by a suitable minimum college entrance examination. This should partake of the "intelligence-test" type of examination to test natural thinking and reasoning ability and should be supplementary to the qualifications indicated by high-school or preparatory-school standing. Evidence of adequate training in English should be required through examination at entrance, and further training provided during all four years of college. A definite standard of attainment should be required for graduation.

The desirable educational standard can be made possible in engineering colleges only by the selection of the ablest from a number of applicants. This may seem severe, but it must be remembered that even now there are many more engineering graduates in this country than can be absorbed profitably by industry. Industry has no use for "duds" and the preliminary sorting out can be done most soundly and economically at the engineering college.

If the industrial employer could be assured that by going to a certain institution he could feel certain that any graduate that he selects must have been thoroughly qualified, he would go there first for his selection of men. Such an institution would have several applications, even in depression years, for each of its graduates. The reputation of such an institution as evidenced by the demand for its graduates would in turn attract the highest type of applicants in adequate numbers to permit the desired selection, just as a successful football team attracts the best football material.

SUBJECT MATTER VS. MENTAL TRAINING

As it has been pointed out, engineering schools seem to vie with each other in publicizing extensive undergraduate curricula in which subject matter is stressed rather than training. The idea seems to be that the best college is the one which has the most elaborate and extensive curriculum with special emphasis on laboratory courses. Having announced such a full curriculum, good faith must be kept by trying to carry it through. Herein, to my mind, lies the cause of many of the principal defects observed by employers in present-day education. The student is expected to learn more and more in a given time and the courses must be made "easy" so he can accomplish the work laid out in the curriculum. To obtain high or even passing marks, he must memorize extensively—he cannot take time to think. The main purposes of an engineering education, a thorough understanding of principles and training in the use of the mental "tools" of the profession, are thus defeated. Training in thinking is far more important than the mere acquisition of factual knowledge. Employers do not want human slide rules or walking encyclopedias of engineering knowledge. They want graduates trained in logical thinking, in habits of thoroughness, and in the scientific method of approach.

In practically no technical school in America today can the complete curriculum, as announced, be followed through successfully and at the same time give the student an opportunity to achieve a thorough understanding and mastery of the elements of the subjects which he is studying. An exception may be made in the case of unusually gifted students who are able to cover the required ground and still have time remaining for thoughtful study.

In engineering education, the aim should be to have no fact or theory accepted until it is first thoroughly understood. Memorizing without thorough understanding does not develop the habit of mind that is so necessary in later life to the successful engineer. On the contrary, it leads to a habit of taking things for granted, and often to a feeling of mental helplessness and inferiority fatal to mental progress in later life.

The engineer who advances the boundaries of his profession must have curiosity and an inquiring mind. These natural

mental attributes should not be deadened or stultified in the process of technical education, but should be stimulated and developed. The student should be encouraged and required to do everything for himself that he can accomplish through his own mental processes without recourse to text or oral instruction. Teaching, should be through guidance rather than through enforced assistance. The inductive method should precede the classical and commonly overdone deductive method.

Furthermore, it is doubtful if our colleges today have the properly trained personnel in sufficient numbers to follow successfully any system of instruction other than that which is now so generally employed. In general, instructors teach others in the same manner that they themselves have been taught. The majority place too much dependence on slavish following of texts which are written more from the standpoint of reference books than teaching texts. Real teaching must be independent of such texts and must be individualistic with the fundamental educational aim in view. Such teaching cannot be mechanized. The text should be used primarily as a review and as a means of consolidation of what has already been taught. There are very few texts which are arranged ideally for the inductive presentation of the elements of a subject. The student's power of perception should be trained. He should be taught how to gain and apply knowledge independently of texts. This ability distinguishes the great engineer from the mediocre.

Very much more time should be allotted to the mastery of the elements of a subject, largely by the inductive method, and very much less time spent on the presentation of the more extensive details of the subject. Thoroughness should be aimed at rather than completeness. Furthermore, the lecture method of presentation is often overdone and wholly fails to accomplish the purpose for which it is intended. The requirement of lecture notes in undergraduate training is practically useless and a waste of time and energy. It is the antithesis of proper teaching.

To improve methods in technical instruction, instructors must be far better trained in teaching methods and it must be recognized that such training is equally if not more important than the proper mastery of the subject itself by the instructor. There is today no adequate training in colleges for instructors in their art. This should become a faculty duty, and must be so if we are to improve methods of education. Instructors must be taught how to teach and be imbued with the proper ideals of education. Today we have many teachers but few educators.

To be successful in undergraduate work, faculties must be headed by great educators. The best educators, contrary to common practice, should be placed in charge of freshmen and sophomore classes where it is necessary to start the student on the right path, and the best talent should not be left for the junior and senior classes as at present. If the freshmen and sophomore years are taken care of as they should be, there need be little worry about the results of instruction in the junior and senior years. It must be appreciated that few students have had the advantage of proper educational training in secondary schools and this defect must be overcome in the first two years. Under the present system, the freshman usually progresses as best he can and consequently the educational results of this year are usually deplorable. When the student awakens sometime in his senior year, as he may, it is then too late for him to retrieve lost opportunity. It will not be denied that many students achieve brilliant success in afterlife under the existing system, but for the most part it is in spite of the system of education rather than because of it.

DEVELOPMENT OF STUDENT PERSONALITY

There is a tendency in our schools to overemphasize the technical side of education at the expense of the human aspect. The engineer's success depends fully as much on his ability to deal successfully with human problems as it does upon his ability to deal with mechanical problems. Indeed, if a man possesses the latter ability without the former, he may be a failure, even as an engineer, while with the former, even without the latter, he will at least succeed as a man. It has been truly stated that few engineers lose their jobs because of lack of technical ability. Jobs are lost largely because of failure in human relations.

Many believe that the important subject of human relations can be taught only through environment and example. I must confess that I, too, was once of this opinion. However, this essential element of education should not be left wholly to chance. One has only to read Dale Carnegie's book "How to Win Friends and Influence People" to realize this. I recommend this as required reading by both faculty and students.

The importance of this phase of education is becoming more appreciated in some colleges. Although emphasized in so-called courses of administrative engineering, it should not be neglected in any technical course. It is almost as important for the success of research engineers as it is for those in executive positions.

A technical college which has on its faculty a preponderance of "cloistered" professors cannot be a wholly successful college. Too academic an atmosphere is not healthful—especially to those students who are most in need of stimulation and guidance in social relations. Too often the excellent student as well as the college professor is, or tends to become in parlance of the psychologist, an introvert and needs help in overcoming this tendency.

SYSTEM OF STUDENT GRADING

Another failure of engineering schools, from the employer's standpoint, is that he finds difficulty in selecting a man on the basis of his standing in college. The student with apparently the best standing may be merely a "memory machine" and therefore of little value to the employer. The turnover in the employment of young engineers is altogether too great. The employer can obtain some idea of the personality of the student from an interview, but he must rely wholly upon the college standing of the young graduate for an appraisal of his mental ability. Since today a student's standing, as evidenced by his "marks," merely indicates his application (which is valuable) and his ability in memorizing facts and formula, it does not disclose, at least independently, his ability in perception and reasoning, which is one of the chief characteristics in which the employer is interested. Better to appraise the student of his educational progress and to aid the employer in his judgment in the selection of engineering graduates, an entirely different system of marking must be employed. While it must be admitted that examinations employing a system of marking are useful and necessary, far greater stress should be put upon a thorough understanding of principles and their application, rather than upon factual knowledge or facility in engineering calculations. Where a passing mark of 60 per cent is now required indiscriminately, there should be two examinations; the first, to test the thorough understanding of essential principles, should require a passing grade of 80 per cent; and the second, to test factual knowledge and facility in engineering calculations, may require only 60 per cent. This is based on the theory that a man who doesn't understand what he is doing will never make an engineer.

Most of the foregoing criticisms and suggestions were embodied in a paper[1] presented by the author before this Society in 1937, and also set forth in the admirable S.P.E.E. "Report of the Committee on Aims and Scope of Engineering Curricula."[2]

[1] "Principles Vs. Curriculum in Memorizing Facts and Theories," by W. H. Carrier, MECHANICAL ENGINEERING, 1937, p. 351.

[2] See pages 727–730 of this issue.

COOLING *the* CONCRETE *of* GRAND COULEE DAM

By CLARENCE RAWHOUSER

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CONTROL of the temperature of concrete structures has long been recognized as desirable in order to control the volume change and cracking of the concrete attendant with large temperature changes. Methods accomplishing some degree of control, some of which have been used in construction of all important massive structures built of concrete, include limiting the depth of lift, regulating the time interval between successive lifts, restricting placement to favorable time of year, carefully considering contraction joints, limiting dimensions of the structure, leaving open joints or slots between blocks until after the blocks have cooled and shrunk, limiting the cement content, using special cements, controlling the initial temperature, evaporative cooling by sprinkling the surface, selecting the type of forms, and controlling the time of removal of forms.

The artificial cooling of massive concrete structures, such as concrete dams, is definitely established as the most effective means of controlling the temperature of the concrete. Furthermore, the most satisfactory, most flexible, and for the degree of control obtained, the most economical method of artificially cooling the concrete is by circulating cold water through a pipe system embedded in the concrete. At Grand Coulee Dam, water obtained directly from the river, without treatment of any sort, has proved to be quite satisfactory for cooling the concrete to the desired temperature before the reservoir attained considerable depth. Cooler water is to be available from the reservoir this fall through the use of a cooling tower.

THE NORMAL TEMPERATURE STATE

The temperature might be more readily controlled if concrete were an inert material whose temperature depended only upon exterior conditions. However, the hydration of the cement, without which concrete as we know it cannot be produced, is a heat-producing reaction responsible in itself for changes in temperature sufficient to cause cracking of the concrete. The ideal condition would be to place the concrete at that temperature which it would attain by virtue of its ultimate exposure conditions, and prevent any temperature change in the construction and intermediate periods. The normal temperature state of a concrete dam is vastly different from such an ideal.

The temperature of the concrete at the time of placing is usually about that of the mean monthly air temperature at the location of construction unless special measures are taken to control this initial temperature. At Grand Coulee Dam, where the mean annual air temperature is about 46 F, and the mean monthly air temperature varies from 22 F in midwinter to 67 F in midsummer, the average concrete temperature at the time of placement varied from 50 to 75 F as shown in Fig. 1. During freezing weather, the concrete materials were heated and the concrete was protected so that initial temperatures were at no time less than 40 F. During extremely cold weather, when adequate protection became extremely difficult and costly, concreting was discontinued.

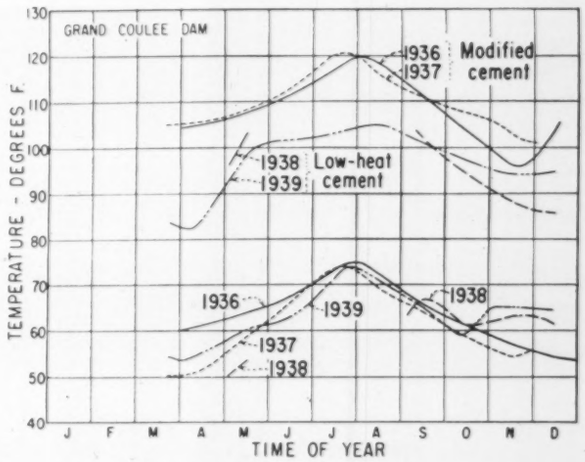

FIG. 1 INITIAL AND MAXIMUM CONCRETE TEMPERATURES

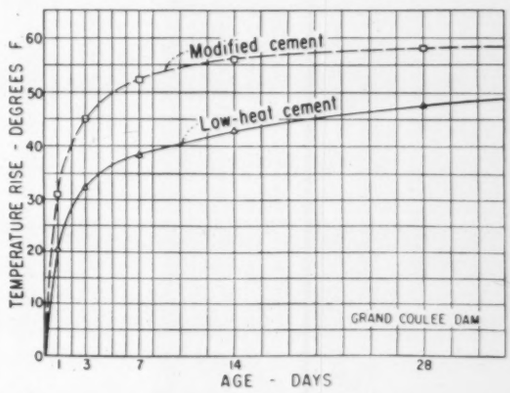

FIG. 2 ADIABATIC TEMPERATURE RISE IN MASS CONCRETE FOR TWO TYPES OF CEMENT

The two types of cement used, first modified Portland and later low-heat Portland, are reflected in the difference in maximum temperatures of the concrete containing the different cements. Under adiabatic conditions the temperature rise of concrete containing 1.0 bbl of cement per cu yd of concrete, the proportions used for Grand Coulee Dam, for the two types of cement is as shown in Fig. 2.

The greatest difference in the temperature characteristics of the two types of cement is in the rate of heat generation during the early age. The slower rate of heat generation and the lower total amount of heat developed by low-heat cement are factors favoring its use in massive structures. Under ordinary conditions of placement, some of this excess heat is lost during the period of construction from the top of the lift of concrete before the succeeding lift is placed, from the sides of the blocks,

Contributed by the Heat Transfer Group and presented at the Fall Meeting, Spokane, Wash., Sept. 3–6, 1940, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

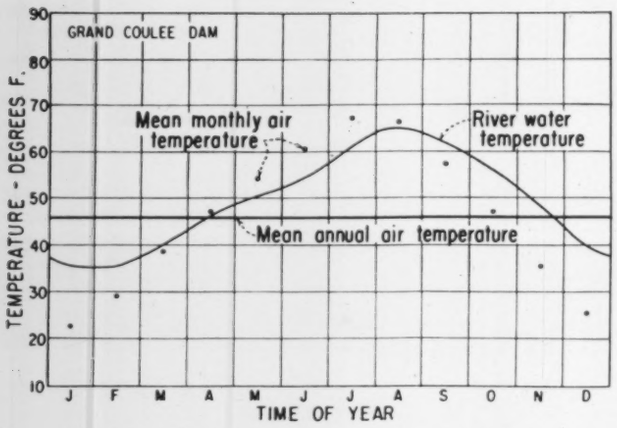

FIG. 3 AIR AND RIVER-WATER TEMPERATURES

or to openings or other permanently exposed surfaces. The loss of heat to the exposed surfaces is usually not large, and maximum concrete temperatures as high as 132 F have been recorded at Grand Coulee Dam.

The temperature of Grand Coulee Dam must ultimately approach the mean annual air and water temperature to which the dam is exposed. In a body of water as deep as the Grand Coulee reservoir, into which flow large volumes of very cold water during at least part of the year, the temperature in the lower part of the reservoir will remain constantly close to the temperature of water at maximum density, 39.2 F. The mean annual temperature of the river water is about 49 F. The final stable temperature of the concrete, therefore, must be from 40 to 49 F on the upstream side to 46 F on the downstream side, with only the surface layer of approximately 20 feet affected by the fluctuations in exposure conditions. It was decided to cool the concrete to 45 F.

THE PROBLEM

The volume change accompanying the temperature change from the maximum to the final stable temperature is the largest to which the dam will ever be subjected. The tension stresses resulting from restraint to free volume change and from the development of large temperature gradients throughout the concrete during the period of adjustment are greater than the concrete can withstand and, unless preventive measures are taken, the concrete will crack in all directions at fairly close spacing. Such cracks cannot help but destroy the continuity, and affect the stability of the structure, as well as detract from the appearance and reduce the period of usefulness by providing focal points for erosion and disintegration.

The problem then becomes that of so controlling the construction operations as to obtain the most favorable temperature conditions without being unduly restrictive; of providing contraction joints where cracks cannot otherwise be prevented in locations and directions least undesirable and so keyed that stress might be transmitted across the joints, with provision for later grouting the joints to restore the structure to the monolithic condition contemplated in the design; and of cooling the concrete so that excessive temperature gradients will not be established and complete volume change will be effected during the construction period. In so cooling and shrinking the concrete to its least volume, the contraction joints will be opened to their widest extent, facilitating the grouting of these joints and preventing further volume change.

Study of the cooling possibilities and the requirements at Grand Coulee Dam indicated that satisfactory cooling could be accomplished with the use of water directly from the Columbia River. The temperature of the river water varies as shown in Fig. 3. During three months of the year the temperature of the water is less than 40 F, during which time the concrete can be effectively cooled to the desired temperature of 45 F. At other times of the year cooling cannot be completed to the desired temperature but effective reduction from the maximum temperature may be obtained. It is desirable to start cooling the concrete as soon as possible after placement, since in so doing a lower maximum temperature is obtained, steep temperature gradients from the interior to the exposed surfaces are prevented, and the temperature is reduced uniformly to almost the final stable temperature during the early age of the concrete.

DESCRIPTION OF THE SYSTEM

Successful experience in cooling the concrete of Boulder Dam indicated no essential change in the embedded system used there for that required at Grand Coulee Dam. Coils of 1-in-outside-diameter tubing averaging about 650 ft long were used. No coil length was allowed to exceed 1200 ft. The pipes were laid on the top of each 5-ft lift of concrete and spaced 5 ft 6 in. apart. At Boulder Dam the embedded coils extended to a slot through the dam where the header connections were made. The requirement of allowing the water to flow over Grand Coulee Dam during each flood season precluded the use of slots as at Boulder Dam or of cooling from either the upstream or downstream face. Accordingly, the embedded coils extend to 3-ft-6-in-diameter shafts where connections are made to 4-in. risers carrying supply and return water. Connection of the risers to the embedded coils is through special manifolds and rubber-hose connections with valve control for each embedded coil permitting the flow to be regulated or discontinued in any coil without affecting the remainder of the system. The shafts extend between horizontal galleries, both transverse and longitudinal, at each 50-ft level, which carry main headers and branch headers to which the risers are connected. Water from the river upstream from the dam is forced by pumps located on barges through the intake pipes embedded in the concrete and extending from the upstream face to the longitudinal galleries, thence through the main headers located in the longitudinal galleries, the branch headers in the transverse galleries, the risers in the vertical shafts, and then through the embedded 1-in. coils. The return water passes in reverse order to main return headers whence it is wasted to the river. The system differs in no essential way from any other water-distributing system, the only unique fea-

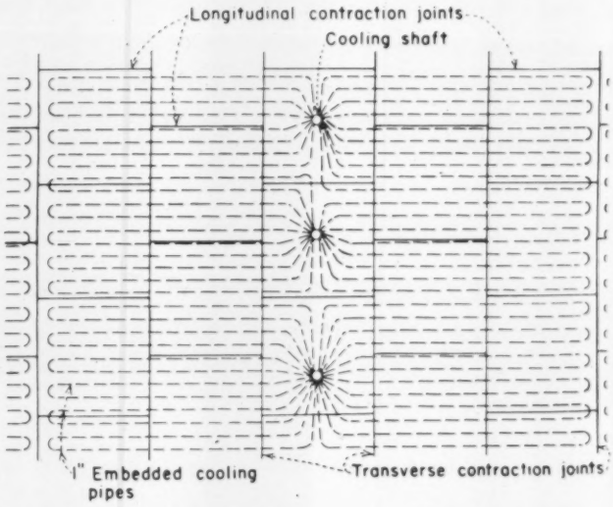

FIG. 4 SECTIONAL PLAN OF CONCRETE COOLING SYSTEM AT GRAND COULEE DAM

ture being the superlative quantities involved. To complete the cooling of Grand Coulee Dam requires the use of about 2000 miles of embedded 1-in. pipe, of 2 miles of vertical $3^1/_2$-ft-diameter cooling shafts, and $5^3/_4$ miles of galleries, transverse and longitudinal, in which the cooling headers are located.

Two pump barges were constructed, one containing six pumps having a total rated capacity of 5500 gal per min at 220 ft of head, and the other housing five pumps rated at 3500 gallons per minute at 220 ft of head. As construction proceeded to higher elevations booster pumps were added enabling the same total quantity of 9000 gal per min to be raised 330 ft.

The general layout of embedded coils and location of cooling shafts for the lower part of the dam are shown in Fig. 4. Six rows of cooling shafts were required in the length of the dam. At higher elevations, as the width of the dam decreased and the length increased, requiring additional rows of shafts, the layout was changed to eliminate the transverse galleries and have the shafts extend between the longitudinal galleries.

PROCEDURE IN COOLING—CERTAIN FACTORS INVOLVED

Cooling was started after the coils within a cooling zone at each 5-ft level were completed with the construction of the lowest block in that zone to the required level, and as soon thereafter as the connections could be made to the risers in the cooling shafts. Every effort was made to have cooling follow the construction level as closely as possible. The flow was distributed so that at least 4 gal of water per min were flowing through each coil at all times. During the season of the year when final cooling could not be accomplished, cooling was continued until the temperature of the concrete was lowered to within 5 to 8 degrees of the river-water temper.. ures. Cooling was then discontinued until such time as effective cooling could again be accomplished, when it was resumed until the temperature was reduced to less than 45 F. The capacity of the pumping plant was such that all concrete available to be cooled each winter season could be cooled to 45 F before the river-water temperature rose too high, in order that contraction joints could be grouted immediately thereafter.

Certain construction features such as the final alignment of the drum gates and the construction of the bridge over the spillway section are dependent upon the prior cooling of the concrete and grouting of the contraction joints, so that it is imperative that the cooling and grouting keep pace with the construction. Fig. 5 shows the region cooled as of March 1, 1940.

At that time 8370 gal of river water per min were being pumped through 2093 coils. The temperature of the water was 39.1 F. All of the concrete below the singly shaded area had been cooled to less than 45 F and the contraction joints were then being grouted in the abutment sections between elevations 1000 and 1050, and in the spillway section 950 to 1000.

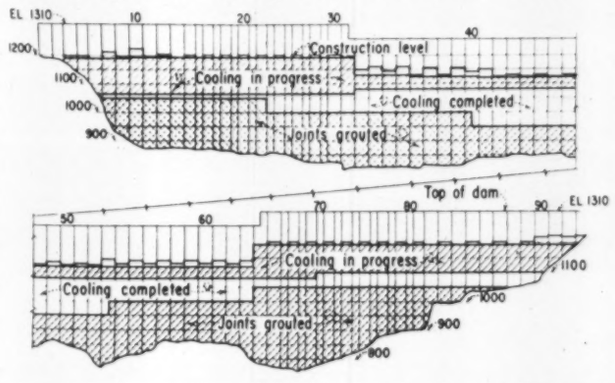

FIG. 5 COOLING PROCESS AT GRAND COULEE DAM AS OF MARCH 1, 1940 (UPSTREAM ELEVATION)

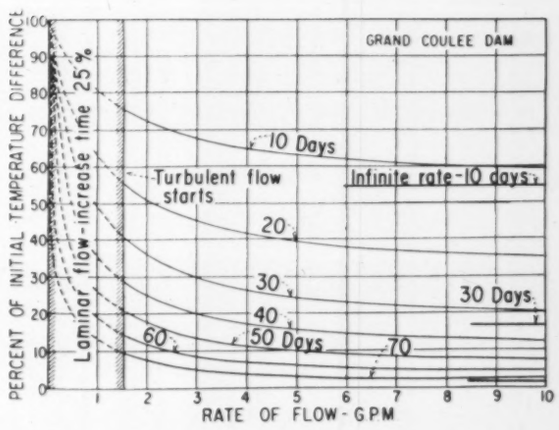

FIG. 6 EFFECT OF RATE OF FLOW THROUGH COOLING PIPES

Circulation of water for 60 to 90 days was ordinarily required to cool the concrete to the desired temperature. Factors in the time required are the size, spacing, and length of the embedded coils, the rate of circulation through each coil, the thermal characteristics of the concrete, and the percentage of the total temperature differential between the hot concrete and the cold water that was required to be removed. The economy of cooling is also dependent on these same factors as well as the design of the system and procedure finally adopted which are based upon comparative studies of cost and performance. The effect of increasing the rate of flow through the 1-in. pipes is illustrated in Fig. 6. The curves shown are computed for coils 600 ft long, with pipe spacing of 5 ft vertically and horizontally, embedded in concrete having a diffusion constant of 0.045 ft squared per hr. The curves of heat removed, plotted against rate of flow, show a marked improvement in performance by an increase in flow up to about 4 gal per min. The curves flatten beyond that point and doubling the flow above 4 gal per min only improves the performance slightly, whereas it doubles the capacity requirements, increases the friction losses, and more than doubles the power costs.

A factor which generally cannot be controlled but which materially affects the rate of cooling and the performance of the cooling system is the coefficient of diffusivity of the concrete. This coefficient varies over a large range for different concretes depending chiefly upon the type of aggregate used. The concrete of Grand Coulee Dam has a value of 0.030 ft squared per hr which is one of the lowest experienced in Bureau of Reclamation dams. In comparison, the concrete of Seminoe Dam, in Wyoming, has a value of 0.060 ft squared per hr. Since the time required to cool under given conditions varies inversely as the diffusion constant, it is apparent that the concrete of Grand Coulee Dam under identical exposure conditions requires twice as long to cool as the concrete of Seminoe Dam.

CONTROL OF THE COOLING—RESULTS

The principal control of the operation of the cooling system is the observance of the temperature of the concrete. The temperature is obtained chiefly from some 1280 resistance thermometers embedded in the concrete at locations which give representative values of the concrete temperatures. Special resistance thermometers are also available which can be inserted in cooling pipes after the flow is discontinued or in other pipes embedded for that purpose to obtain temperatures at other locations. The flow of water is measured at the pumps and can be regulated at many points in the system.

From what has already been said it is apparent that the concrete is being cooled to an estimated final stable temperature

during the construction period and as part of the construction operations. Fig. 1 shows the average maximum temperatures attained by the concrete. Typical temperature-time curves for concrete placed at different times of the year, obtained from thermometers embedded in the dam, are shown in Fig. 7.

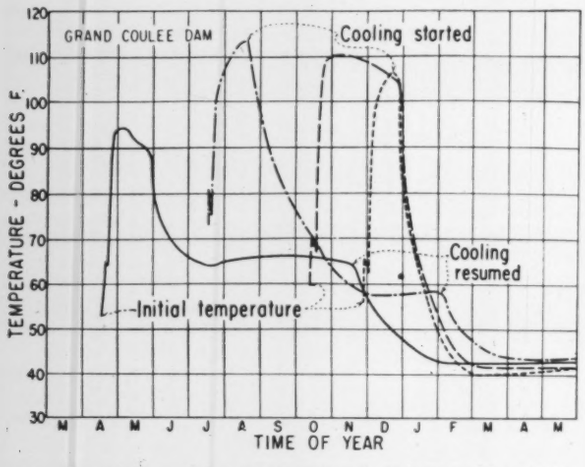

FIG. 7 TYPICAL CURVES OF TEMPERATURE OF CONCRETE

As a result of cooling, the contraction joints have opened uniformly from 0.06 to 0.12 of an inch as indicated by surface measurements and by the uniform acceptance of an average of 1.0 cu ft of cement grout for every 100 sq ft of contraction-joint area. When it is considered that the contraction-joint area of Grand Coulee Dam and pumping-plant dam is about 11,000,000 sq ft, it is possible to picture the large volume that, but for the temperature control exercised, eventually would be encompassed in cracks throughout the structure. There were very few cracks observed on the sides of the blocks intermediate of contraction joints, and none that extended entirely through a block. There are a number of surface cracks in many of the galleries and on some of the exposed faces, the result undoubtedly of steep temperature gradients and to some extent of shrinkage due to loss of moisture at those locations, but these cracks, although undesirable, are considered to be superficial and not of structural importance.

REQUIREMENT FOR COOLING TOWER TO COMPLETE THE COOLING

It is estimated that the normal temperature of the river water available this coming fall and winter will be unfavorably affected by the storage this summer of a large quantity of warm water. Normally the river-water temperatures drop rapidly during the months of September, October, and November as indicated in Fig. 3. With a reservoir of 1,500,000 acre-ft of water at about 65 F, the colder inflowing water must mix with this warm mass and the entire volume must be reduced to 40 F before the surface water will fall below that value and approach freezing temperature. Water sufficiently cold for final cooling, therefore, will not be available until much later than normally.

Since it is desired that cooling be not unduly delayed this winter season, in order to allow adequate time to grout the contraction joints and complete the necessary construction before the flood season of 1941, it was decided to use a cooling tower this fall to assure that water cold enough to complete the cooling will be available even though the reservoir water may be unfavorably warm. An atmospheric-type, deck-filled tower will be used, having the capacity to cool 5500 gal per min of water from 54 F to 48 F with a wet-bulb temperature of 34 F and a wind velocity of 3 miles per hr. The cooling tower will be so located that when it is in use the water will be pumped to the top of the tower and will flow by gravity from the basin of the tower through the cooling system.

COST OF COOLING GRAND COULEE DAM

The large quantities involved, the use of cooling water directly from the river, and the efficient use of plant and equipment have resulted in a lower unit cost for cooling the concrete of Grand Coulee Dam than for any other dam constructed and cooled to date by the Bureau of Reclamation. The costs presented are not complete in that the project is not yet finished, and are not given in detail but represent all of the major items of cost chargeable to cooling.

Grand Coulee Dam has been constructed under two general contracts; the lower part of the dam by Silas Mason Company, Walsh Construction Company, and Atkinson-Kier Company, and the upper part by Consolidated Builders, Inc. Under the first contract, involving some 4,250,000 cu yd of concrete, the unit cost of cooling was about $0.128 per cu yd which was divided between major items as follows:

Installing embedded metal tubing and fittings:	
Contract earnings	$0.036
Cost of materials to the government	0.035
Furnishing and installing headers, connections, and equipment, except embedded materials, and operating cooling system:	
Contract earnings	0.031
Cost of materials to the government	0.014
Additional work done by government, including cooling-control costs	0.012
Total	$0.128

Under the second contract, involving some 4,400,000 cu yd of concrete placed to March 1, 1940, the unit cost was about $0.145 per cu yd which was divided as follows:

Installing embedded metal tubing and fittings:	
Contract earnings	$0.058
Cost of materials to the government	0.043
Installing and dismantling headers and fittings:	
Contract earnings	0.019
Cost of materials to the government	0.001
Operating cooling plant and system	0.018
Additional work done by government, including cooling-control costs	0.006
Total	$0.145

By the time cooling is completed, the unit cost under the present contract will probably be higher due to the greater proportion of operating costs to the concrete still to be placed and due to the installation of the cooling tower. It is estimated that the unit cost under the present contract, for the 5,500,000 cubic yards to be cooled, will not exceed $0.155 per cu yd. Upon this basis, the total cost of cooling the 9,750,000 cu yd of concrete will be approximately $1,400,000 or $0.144 per cu yd.

ACKNOWLEDGMENTS

Most of the studies of the requirements for cooling Grand Coulee Dam, leading to the selection of the scheme used and the plant capacity and procedure adopted, have been performed by the writer or under his immediate supervision. The design and construction of dams for the Bureau of Reclamation are directed by K. B. Keener, designing engineer on dams; J. L. Savage, chief designing engineer; and S. O. Harper, chief engineer, with headquarters in Denver, Colorado. All activities are directed by John C. Page, commissioner of reclamation, Washington, D. C.

OXYGEN BOOSTING *of* AIRPLANE DIESEL ENGINES

By P. H. SCHWEITZER

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WHILE moderate changes in the oxygen-nitrogen ratio of the intake air have been tried by Boerlage and Van Dyck (1)[1] and the British Aeronautical Research Committee (2), the full possibilities of the oxygen for power boosting the Diesel engine have never been explored to the knowledge of the author. The main question was not whether the engine would respond to the oxygen feed but whether or not it would be able to stand it. The experiments herewith reported supplied a favorable answer.

A $3^1/_4 \times 4^1/_2$-in. four-stroke C.F.R. Diesel engine was used. The compression ratio was kept 15.8 to 1 and the engine speed at 890 ± 2 rpm during the tests. The instrumentation included gasmeter, kilowattmeters, smokemeter, exhaust pyrometer, ignition-lag indicator, and a 9-in. cathode-ray oscillograph which showed the cylinder pressures and the rates of pressure change continuously during the tests. Fig. 1 shows the setup schematically and Fig. 2 photographically.

The final results of the investigation are reproduced in Fig. 3, where the essential characteristics are plotted against the intake air-oxygen concentration. By increasing the oxygen concentration from the normal 21 per cent to 45 per cent, the indicated horsepower increased from 4.3 to 6, the brake horsepower from 2.9 to 4.65, the maximum cylinder pressure from 700 to 780 psi, the maximum rate of pressure rise, which is an index of the shock loading of the engine, *decreased* from 88 to 60 psi per deg, together with the ignition lag which was shortened from $9^1/_2$ to 5 deg. The specific fuel consumption increased from 0.43 to 0.59 lb per ihp-hr or from 0.64 to 0.76 lb per bhp-hr, and the exhaust temperature increased from 620 to 1000 F under optimum timing conditions and with clear exhaust. The explanation for the favorable showing of the oxygen boost with regard to cylinder pressures and rates of pressure rise is obviously the extremely beneficial effect the oxygen has on the ignition lag which was about cut in half by the oxygen addition.

The deterioration of the specific fuel consumption—of no consequence by itself for a few minutes' operation—is partly due to the stretched injection duration necessary with the small-capacity pump and nozzle designed and adjusted for a much smaller injection quantity.

With 55 per cent oxygen concentration the power figures further increased somewhat, but at above 50 per cent oxygen occasional detonation was experienced.

In Fig. 3, which is used finally to evaluate the performance of the oxygen-boosted engine, every point represents a great number of test readings. The comparison was made at optimum injection timing. This necessitated the determination for every oxygen concentration the injection timing which corresponds to the maximum power output. The injection advance angles so determined are also indicated in Fig. 3. They vary between 10 and $12^1/_2$ deg, depending on the oxygen concentration. Then the comparison should be made at corresponding loads.

Using the absolute maximum load the engine is able to carry is impracticable as under such load the engine soots up quickly. Instead of that, the comparison is based on "50 per cent smoke." The load is increased until the Penn State smokemeter (3) registers 50 per cent smoke density. This incidentally is the approximate limit of "clear exhaust." When the smokemeter registers 50 per cent the exhaust smoke just begins to become visible to the naked eye against a blue-sky background. The Penn State smokemeter is shown schematically in Fig. 4.

By simultaneously measuring power output and smoke, Fig. 5 was obtained, which permitted one to pick the points corresponding to 50 per cent smoke.

The measured power outputs at optimum injection timing and 50 per cent smoke would still be without practical significance if they were accompanied by combustion pressures exceeding the limits of safety or rates of pressure rise causing intolerable knock. An RCA 9-in. cathode-ray oscillograph supplied the information. Figs. 6 and 7 show typical oscillograms under normal and boosted operation. It will be noticed that the oxygen boost does not make the indicator card higher or steeper, only fatter.

For obtaining rate-of-pressure-rise figures directly, electromagnetic pickups (American Instrument Company), instead of piezoelectric, were used. Such a card is shown in Fig. 8; Fig. 9 shows the same electrically integrated. In the latter diagram the bright dots are 10 deg apart and the brightest dot corresponds to top dead center.

For calibrating the cathode-ray records a balanced-pressure method was used as described in (4).

Injection and ignition timing were read directly by an Aminco-Penn State ignition-lag indicator (5).

The power output of the engine was determined by measuring with two kilowattmeters the output of the three-phase 220-v synchronous generators, which in turn was calibrated by a prony brake. The exhaust temperatures were measured with a chromel-alumel thermocouple mounted in a shielded well. The oxygen feed was controlled by a displacement-type gasmeter and stop clock. The power phase of the investigation comprised about 2200 readings.

OXYGEN HELPS STARTING

To determine whether oxygen is a good starting aid a series of reference fuels, from 29 to 72 cetane number, were tested with various degrees of oxygen boost, by determining their critical compression ratios which caused them to ignite within a period of six injections after switching on the injection. The final results are shown in Fig. 10. It is evident that by raising the oxygen concentration from the normal 21 per cent to 45 per cent the minimum cetane number may be lowered by roughly 10

[1] Numbers in parentheses refer to Bibliography at end of paper.

Presented at the 1940 Meeting of the Oil and Gas Power Division, Asbury Park, N. J., June 19–22, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

This paper is an abstract of a thesis for the degree of Master of Science, entitled "Oxygen Additions to a Diesel Engine," by E. R. Klinge, The Pennsylvania State College, 1940, who carried on the experimental work and made most of the calculations.

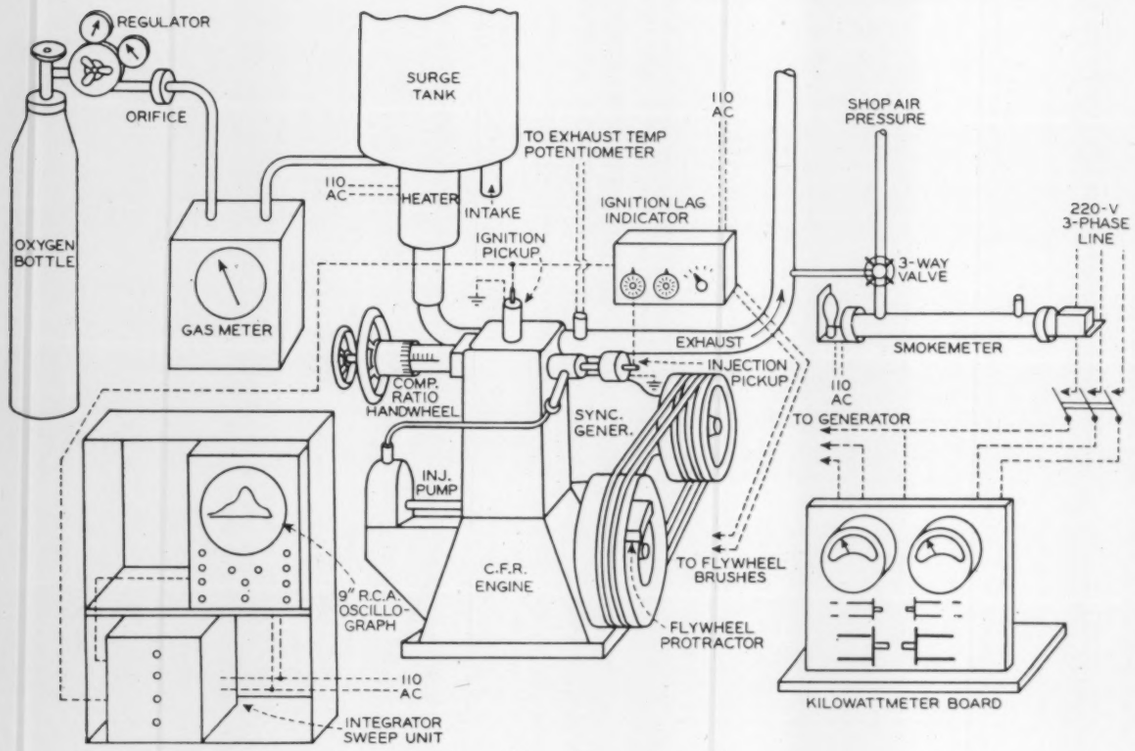

FIG. 1 SCHEMATIC DIAGRAM OF C.F.R. ENGINE AND TEST APPARATUS

units; in other words, the oxygen boost is equivalent to raising the ignition quality of the fuel by 10 cetane numbers. The oxygen addition, however, was much more potent in improving the ignition of the fuel in the running engine. By the Penn State R.C.R. method (6) an oxygen boost from 21 to only 26 per cent was sufficient to raise the apparent cetane number by 10, see Fig. 11.

SMOKE REDUCTION

Fig. 12 shows the effect of a small amount of oxygen on the smoke. Five per cent increase in the oxygen concentration is sufficient to make a black exhaust invisible.

DETONATION

At high oxygen feed, at a rate of 50 per cent concentration or higher, occasional "detonation" was observed. To the ear it was a high-pitch "pink" but lasted for only one or two revolutions at a time. Its occurrence was unpredictable. It was accompanied by an irregular pressure rise and considerable smoke. Fig. 13 is the oscillogram of a detonating combustion superimposed on a number of nondetonating combustions. Below 45 per cent oxygen concentration no detonation was observed.

PRACTICAL CONCLUSIONS

Airplanes require about one third more power during the take-off than in flight. In Diesel-engined airplanes the size of the engine could, therefore, be reduced by 25 per cent in feeding oxygen into the intake air during the take-off. Applying

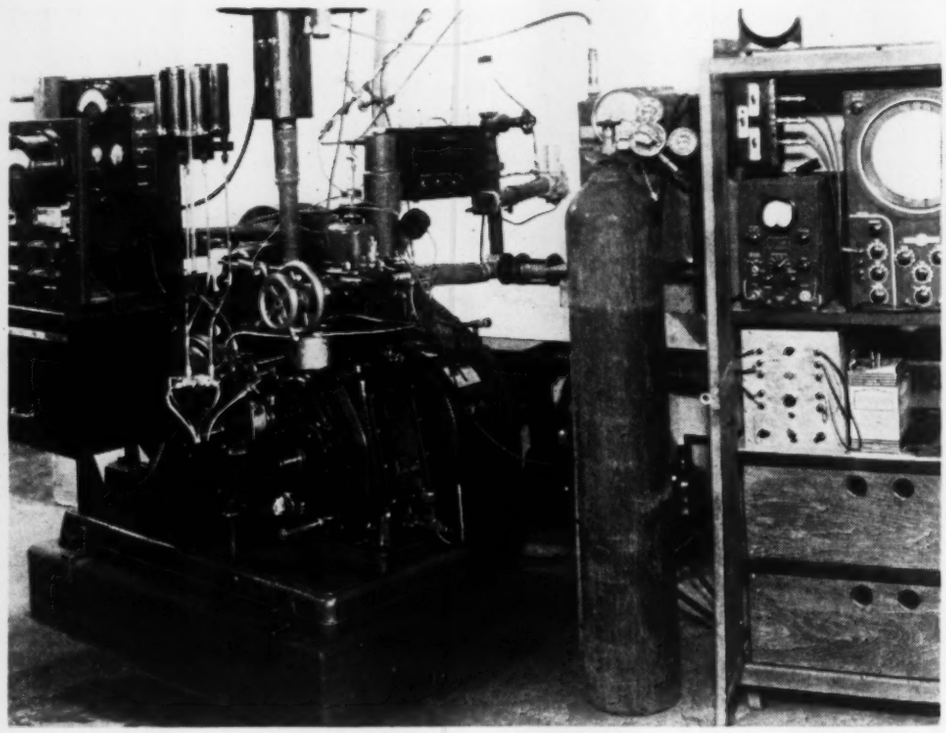

FIG. 2 PHOTOGRAPH OF C.F.R. ENGINE AND TEST APPARATUS

the results of the experiments to a transport plane, Fig. 14 shows the possible weight saving with various oxygen boosts. The curves are based on 6000 cruising hp and an estimated engine weight of 2 lb per hp.

For the take-off 8000 hp are necessary. To supply the additional 2000 hp, 200 lb of oxygen is fed into the intake air during the take-off. The volume of 200 lb of liquid oxygen is 20 gal. Standard liquid-air containers of 55-liter capacity weigh 75 lb. Therefore the weight of the oxygen and container is 350 lb while the possible saving in engine weight is 4000 lb. The weight per take-off horsepower is thereby reduced from 2 to 1.54 lb. The calculation is shown in Table 1.

Oxygen addition may be used for starting Diesel engines.

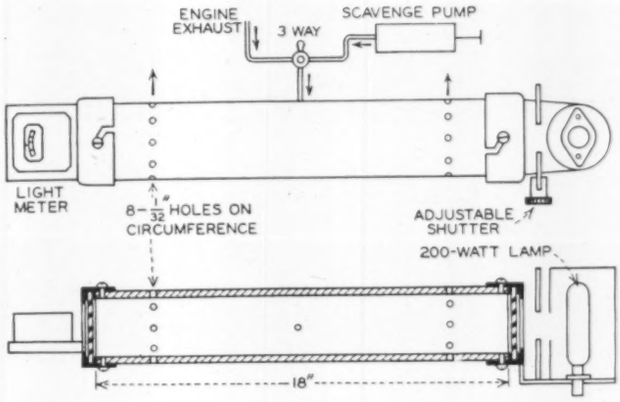

FIG. 4 PENN STATE SMOKEMETER

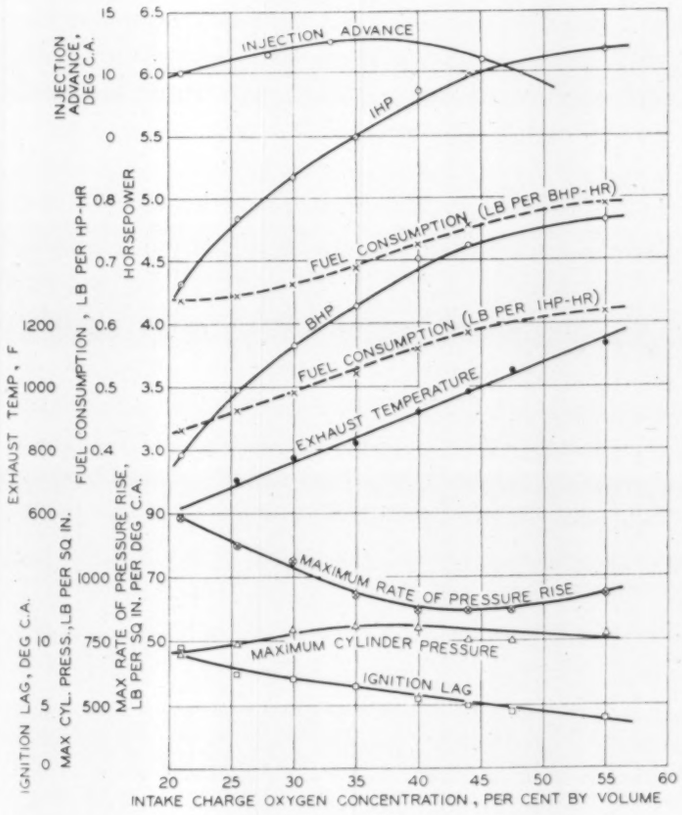
INJECTION ADVANCE, DEG C.A.
INJECTION ADVANCE
IHP
FUEL CONSUMPTION, LB PER HP-HR
HORSEPOWER
FUEL CONSUMPTION (LB PER BHP-HR)
BHP
FUEL CONSUMPTION (LB PER IHP-HR)
EXHAUST TEMP., F
EXHAUST TEMPERATURE
MAX RATE OF PRESSURE RISE, LB PER SQ IN. PER DEG C.A.
MAXIMUM RATE OF PRESSURE RISE
MAXIMUM CYLINDER PRESSURE
IGNITION LAG, DEG C.A.
IGNITION LAG
MAX CYL. PRESS., LB PER SQ IN.
INTAKE CHARGE OXYGEN CONCENTRATION, PER CENT BY VOLUME

FIG. 3 TEST RESULTS, OPTIMUM TIMING CONDITIONS, 50 PER CENT SMOKE

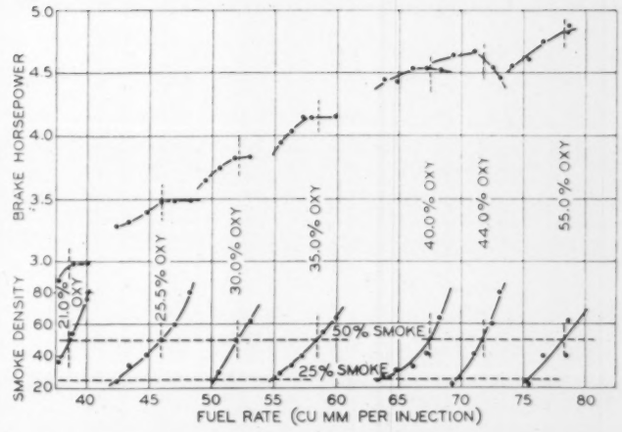

FIG. 5 BRAKE HORSEPOWER AND SMOKE DENSITY AT OPTIMUM TIMING

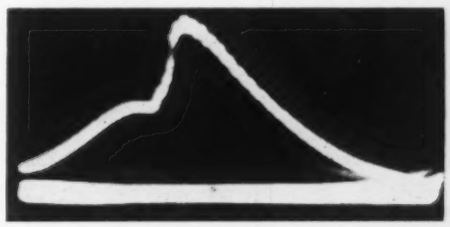

FIG. 6 PRESSURE DIAGRAM, NONBOOST
(2.7 bhp, 21 per cent oxygen content, 32 cu mm of fuel per injection.)

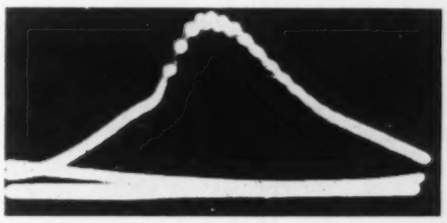

FIG. 7 PRESSURE DIAGRAM, BOOST
(4.65 bhp, 45 per cent oxygen content, 71 cu mm of fuel per injection.)

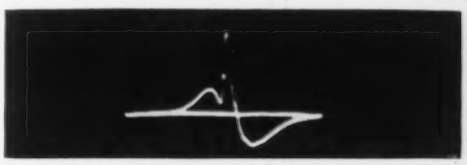

FIG. 8 RATE-OF-PRESSURE DIAGRAM
(2.7 bhp, 21 per cent oxygen content, 32 cu mm of fuel per injection.)

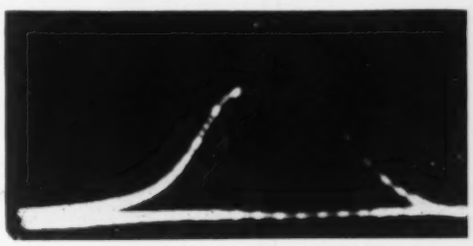

FIG. 9 PRESSURE DIAGRAM WITH DEGREE SCALE
(2.7 bhp, 21 per cent oxygen content, 32 cu mm of fuel per injection. Bright dots are 10 deg apart.)

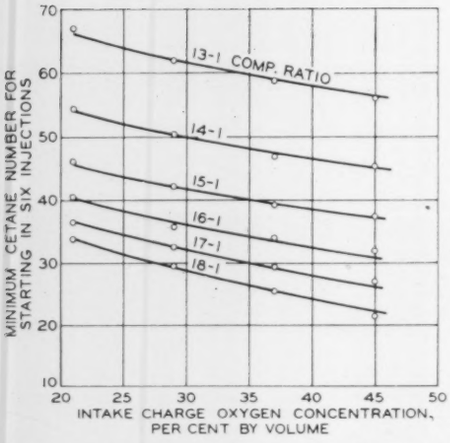

FIG. 10 EFFECT OF OXYGEN ON THE MINIMUM CETANE NUMBER REQUIRED FOR STARTING—C.C.R. DETERMINATION

(600 rpm; intake air, 150 F; jacket-water temperature, boiling; starting points for six injections per trial.)

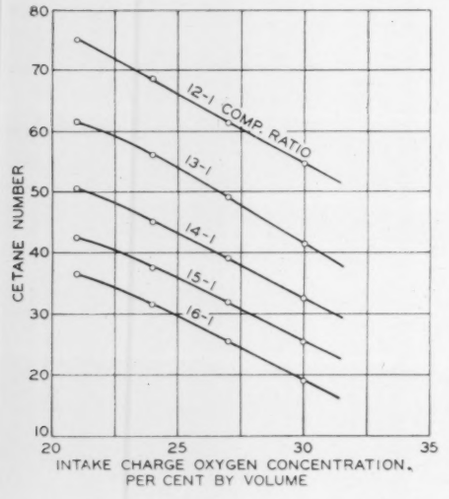

FIG. 11 EFFECT OF OXYGEN ON APPARENT CETANE NUMBER, R.C.R. DETERMINATION

(15-deg ignition lag; ignition, top dead center; 900 rpm.)

The raising of the oxygen concentration from the normal 21 per cent to 45 per cent was found to be equivalent to a raise of approximately 10 cetane number as far as starting is concerned.

Five per cent increase in oxygen concentration eliminated exhaust smoke completely.

TABLE 1

Normal horsepower	6000
Take-off horsepower	8000
Normal air consumption, lb per min	900
Normal oxygen consumption, 21 per cent oxygen concentration, lb per min	189
Boosted oxygen consumption, 32 per cent oxygen concentration, lb per min	289
Oxygen to be supplied, lb per min	100
Weight of 8000-hp engine, lb	16,000
Weight of boosted 6000-hp engine, lb	12,000
Weight of oxygen for 2-min boost, lb	200
Weight of container for 29 lb of liquid oxygen, lb	150
Net weight saving by oxygen boost, lb	3650
Weight per horsepower, nonboosted engine, lb	2
Weight per horsepower, boosted engine, lb	1.54

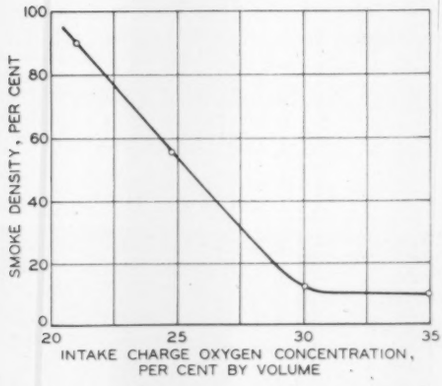

FIG. 12 EFFECT OF OXYGEN ADDITION ON THE EXHAUST SMOKE

(45 cu mm of fuel per injection.)

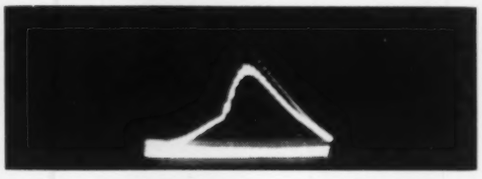

FIG. 13 OSCILLOGRAM OF DETONATING COMBUSTION

(60 per cent oxygen content.)

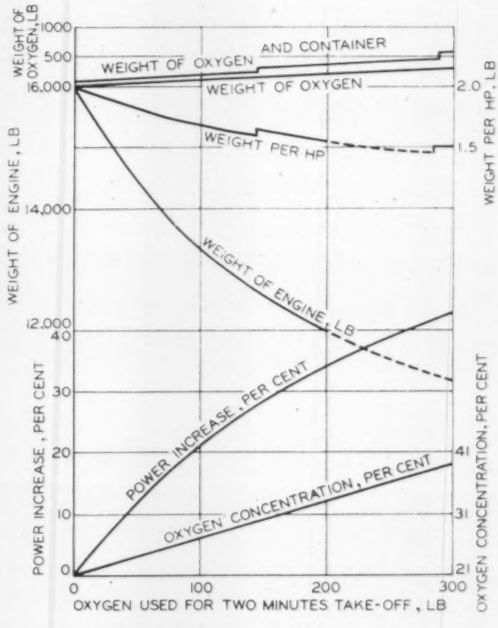
WEIGHT OF OXYGEN, LB
WEIGHT OF OXYGEN AND CONTAINER
WEIGHT OF OXYGEN
WEIGHT PER HP
WEIGHT PER HP, LB
WEIGHT OF ENGINE, LB
WEIGHT OF ENGINE, LB
POWER INCREASE, PER CENT
POWER INCREASE, PER CENT
OXYGEN CONCENTRATION, PER CENT
OXYGEN CONCENTRATION, PER CENT
OXYGEN USED FOR TWO MINUTES TAKE-OFF, LB

FIG. 14 EFFECT OF OXYGEN BOOST ON POWER AND WEIGHT

(Cruising horsepower, 6000; take-off horsepower, 8000.)

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Milwaukee's Contribution to PULVERIZED-COAL *Development*

By HENRY KREISINGER[1] AND JOHN BLIZARD[2]

MILWAUKEE'S contribution to the development of pulverized coal as fuel for making steam has been outstanding. One cannot think of pulverized coal without calling to mind John Anderson and his associates and their pioneer work in advancing the use of pulverized coal. This paper will review briefly the many investigations of fundamental principles involved in the use of pulverized coal.

The burning of coal on grates in fuel beds gave rise to clinker troubles. By eliminating fuel beds, powdered coal corrected this difficulty. Pulverized coal offered a possibility of increasing the capacity of a furnace to burn coal. The capacity of a boiler equipped with a grate is limited by the area of the grate, whereas, the capacity of a pulverized-coal boiler is limited only by the volume of combustion space, which may be amplified either by increasing the area of the horizontal cross section of the furnace or by making the furnace higher or deeper. Pulverized coal also made it possible to burn a greater variety of coals satisfactorily in any one plant.

To determine the best method of burning powdered fuel John Anderson did two things: (1) He made a large-scale trial installation of pulverized coal. (2) He provided the means for testing this fuel system and of analyzing the results which could be obtained with pulverized coal. He also indicated the lines of development along which the system should advance.

The impartial attitude of those conducting the tests and the thorough manner in which they were carried out inspired the confidence of power users who were interested in steam generation and caused them to realize that pulverized coal offered possibilities well worthy of consideration.

The trial installation was completed in 1919 at the Oneida Street Station of the Milwaukee Electric Railway & Light Company on five boilers, each capable of a steam output up to 23,000 lb of steam per hr. Thorough tests of this installation showed results sufficiently satisfactory to justify the installation of pulverized-coal firing under eight large boilers at the new Lakeside Station in 1921. Each of these boilers had a steam output of 50,000 to 100,000 lb per hr.

This large installation was tested very thoroughly and the results showed that the decision in favor of pulverized coal was justified. The results of the tests of both installations were subsequently published,[3] these reports constituting the most thorough and comprehensive of any published up to that time on the use of pulverized coal as fuel for making steam. Subsequent to the Lakeside installation, the use of pulverized coal in central stations increased rapidly.

In both of these installations the bin-and-feeder system, sometimes also called the storage system, was used. The coal was fired in vertical streams downward, the burners being located in a short arch at the top and at the front of the furnace. Coal was mixed only with primary air, secondary air being supplied through the front wall in horizontal streams distributed over the major portion of the front wall. The burning mixture made a U path through the furnace, turning up near the bottom of it. This even distribution of fuel and air in the furnace proved to be the most important factor in burning pulverized coal successfully.

When coal is burned on grates, the coal and the air supply must be distributed uniformly over the grate area. Pulverized coal burns in suspension in the combustion space of the furnace. The coal and the air must be distributed uniformly in the combustion space for the best results. The lack of uniform distribution is the most common cause of poor combustion.

Vertical firing also gave stable ignition and uniform distribution of fuel and air across the furnace with the least impingement of flame against the refractory furnace walls. The stability of ignition makes this method of firing particularly adaptable to burning fuels low in volatile-matter content. It is the only method so far developed that is successful in burning anthracite and coke.

COMBUSTION OF PULVERIZED COAL

The stability of combustion is obtained by mixing only a small part of the air needed for combustion with the coal. It is the volatile matter in the coal which ignites first, after it has been distilled from the coal. A small amount of air with the coal creates a rich mixture with the distilled gas and this ignites readily at a temperature of 1100 to 1200 F. A small weight of the rich mixture requires less heat to raise its temperature to the distillation and the ignition point. The most common cause of unstable ignition is too much air with the coal. Even in the so-called turbulent horizontal burners, the secondary air is kept away from the mixture of primary air and coal until ignition has been started.

Fig. 1 shows the analysis of several gas samples collected simultaneously in the first pass of one of the Oneida Street Station boilers at the points indicated by the dots. The analysis shows that the composition was nearly uniform over the entire pass, which fact indicates good fuel-and-air distribution in the furnace.

A study of furnace temperatures was also made on several tests. Fig. 2 shows one set of temperature measurements at various points in the furnace. The temperature varied from 1500 to 2700 F, depending upon the location within the furnace. The temperature was highest where the combustion process was most intensive. Fig. 3 shows these temperature measurements connected by lines of constant temperatures. The highest temperature zone was about 2 ft above and slightly beyond the shelf where the burning mixture was turned by the shelf

[1] Research Engineer, Combustion Engineering Company, Inc., New York, N. Y. Mem. A.S.M.E.

[2] Research Engineer, Foster Wheeler Corporation, New York, N. Y. Mem. A.S.M.E.

[3] "Use of Pulverized Coal Under Central Station Boilers," by John Anderson, paper presented before the Technical League of the Mutual Benefit Association, Milwaukee Electric Railway & Light Company, Feb., 1920. Because of its historic value in the art of combustion, this paper has also been reprinted by the Combustion Engineering Company, Inc., New York, N. Y.

"An Investigation of Powdered Coal as Fuel for Power Plant Boilers," by Henry Kreisinger, John Blizard, C. E. Augustine, and B. J. Cross, U. S. Bureau of Mines Bulletin No. 223, Washington, D. C., 1923.

"Tests of a Large Boiler Fired With Powdered Coal," by Henry Kreisinger, John Blizard, C. E. Augustine, and B. J. Cross, U. S. Bureau of Mines Bulletin No. 237, Washington, D. C., 1925.

Contributed by the Fuels Division and presented at the Semi-Annual Meeting, Milwaukee, Wis., June 17–20, 1940, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

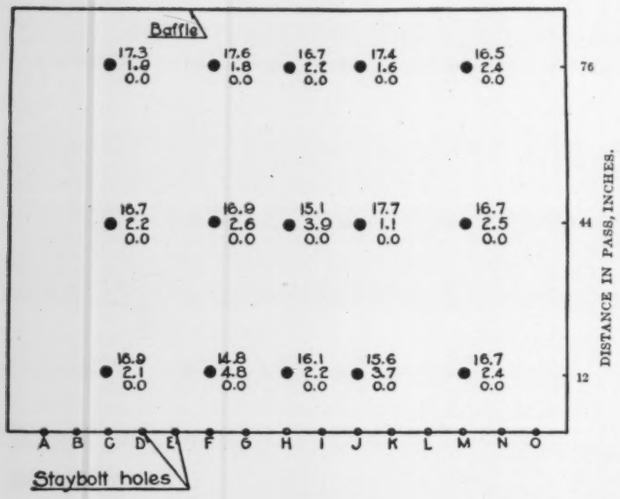

FIG. 1 COMPOSITION OF GAS IN FIRST PASS AT THIRD ROW OF TUBES FROM BOTTOM

(Average CO_2 in pass, 16.5 per cent; at stack 16.6 per cent. Reproduced from ref. 3, U. S. Bureau of Mines Bulletin No. 223, Fig. 47.)

toward the rear of the furnace. The impingement of the stream of burning mixture against the shelf and the sudden change in the direction produced intensive mixing which in turn caused rapid combustion.

Combustion liberates heat which raises the temperature of the burning mixture. The rise in temperature increases the radiation, which is proportional to the fourth power of the absolute temperature of the mixture. Heat travels by radiation to any body which is in the direct path of the radiation. The body may be a boiler, furnace wall, or a body of the mixture in other parts of the furnace which is at lower temperature. High temperature in any part of the furnace generally means high heat liberation in that part of the furnace. When the radiation to other parts of the furnace exactly balances the tendency of the temperature to rise, the temperature remains constant.

The temperature readings represented by Figs. 2 and 3 were used to study the relations between the rate of firing, excess air, and temperatures prevailing in pulverized-fuel furnaces. A chart was prepared and included in Bulletin No. 223,[3] describing the tests at Oneida Street. This chart showed the amount of heat which must have been removed from the products of combustion when these products reached a specified temperature. The chart, Fig. 4, is similar to the one shown originally but, in constructing it, more recent values of the specific heats of the gases have been used. No dissociation of the gases has been allowed for in preparing this chart. When this coal is burned with neither a deficiency nor an excess of air, the heat remaining latent, owing to dissociation, is less than 0.5 per cent at 2700 F, slightly above 1 per cent at 3000 F, and about 7 per cent at 3600 F. Accordingly, dissociation has little bearing on the estimation of the temperatures and heat absorption, although it is interesting to note that, when dissociation is allowed for, the maximum attainable temperature is about 3600 F for this coal burned with air at 90 F.

The highest temperature attained by the thermocouple in the furnace, as shown in Figs. 2 and 3 was about 2700 F; the heat absorbed by the coil at the bottom of the furnace amounted to about 10 per cent of the heat in the coal and the CO_2 was 15 per cent. The chart, Fig. 4, shows that for these conditions the maximum temperature attainable was of the order of 3000 F, or 300 deg higher than the highest temperature measured. This difference is caused partly by additional radiation to the boiler tubes, partly because the combustion process at that point has not been completed, and partly by the thermocouple being at a temperature somewhat below that of the surrounding gases.

On the chart in Fig. 4, two curves (1)-(1) and (2)-(2) may be noted, which show the temperatures at which the gas would

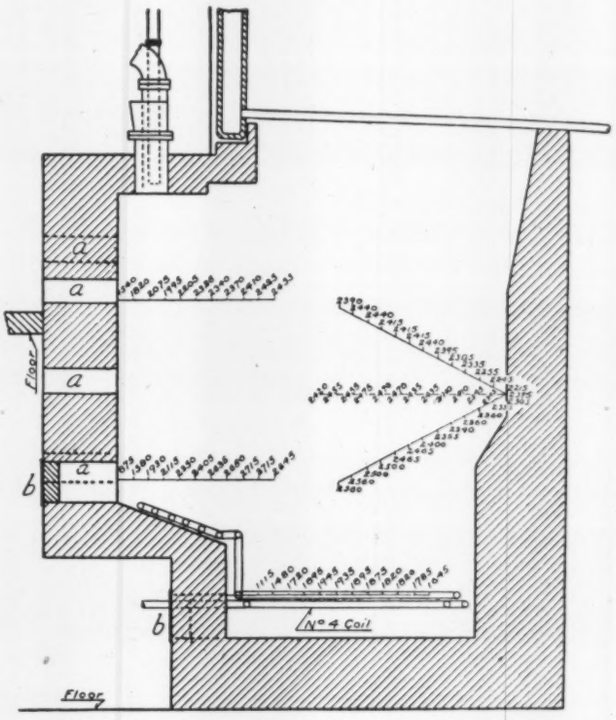

FIG. 2 TEMPERATURE IN FURNACE OF ONEIDA STREET BOILER

(Reproduced from ref. 3, U. S. Bureau of Mines Bulletin No. 223, Fig. 29.)

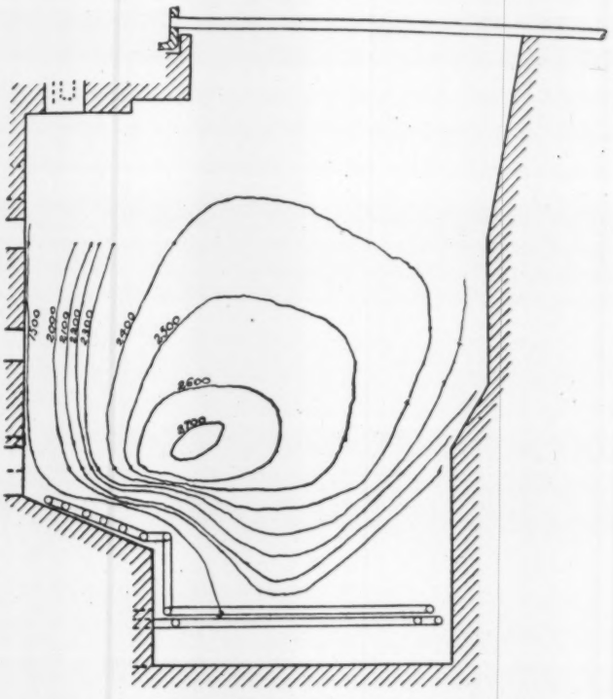

FIG. 3 ISOTHERMALS IN FURNACE, CONSTRUCTED FROM FIG. 2

(Reproduced from ref. 3, U. S. Bureau of Mines Bulletin No. 223, Fig. 30.)

leave the furnace if the rate of heat absorption per square foot of projected area of the opening to the boiler tubes were given by the expression 1700 $(T/1000)^4$, where T, the temperature of the gas leaving the furnace, is in degrees absolute. The upper curve (1)-(1) is for a rate of combustion of 1350 lb of coal per hr and the lower curve (2)-(2) is for a rate of combustion of 2000 lb of coal per hr. The projected area of the boiler aperture was 76.5 sq ft, and there was no cooling coil in the furnace. This empirical method of determining the temperature leaving the furnace was described in Bulletin No. 223,[3] and has been used since by many investigators.

MEASURING TEMPERATURE OF GASES LEAVING FURNACE

The temperature of gases leaving the furnace was measured on several tests. Six bare thermocouples of No. 22 gage wire were inserted through the lowest row of staybolt holes into the path of the gases entering the nest of tubes, and the hot junctions were moved successively in eight positions 1 ft apart. The average of these temperature readings was from 250 to 300 deg lower than the temperature of the gas determined from the chart in Fig. 4. This difference was caused partly by the temperature of the thermocouple being lower than the surrounding gas by an amount which was probably of the order of 100 deg, and also by the fact that the lowest row of stay-bolt holes was above the first row of boiler tubes which absorbed some heat by convection. Fig. 5 shows graphically a set of these temperatures. They are somewhat higher in the rear and on the right side of the aperture, though on the whole fairly uniform. No coil was in the furnace when these temperatures were measured.

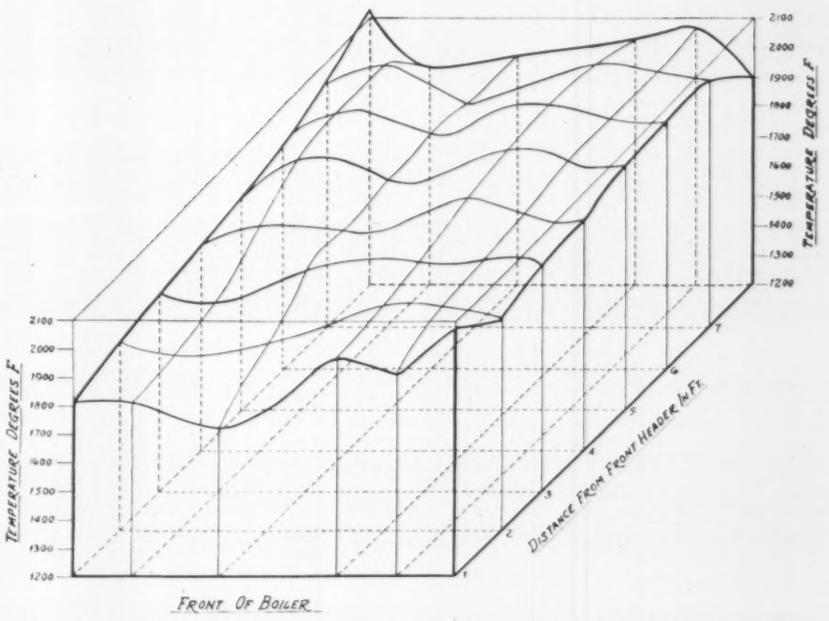

FIG. 5 TEMPERATURE IN FIRST PASS OF ONEIDA STREET BOILER, MEASURED WITH THERMOCOUPLES INSERTED THROUGH LOWEST ROW OF STAY-BOLT HOLES
(Rating 123 per cent; average temperature 1980 F; average CO_2, 14.5 per cent.)

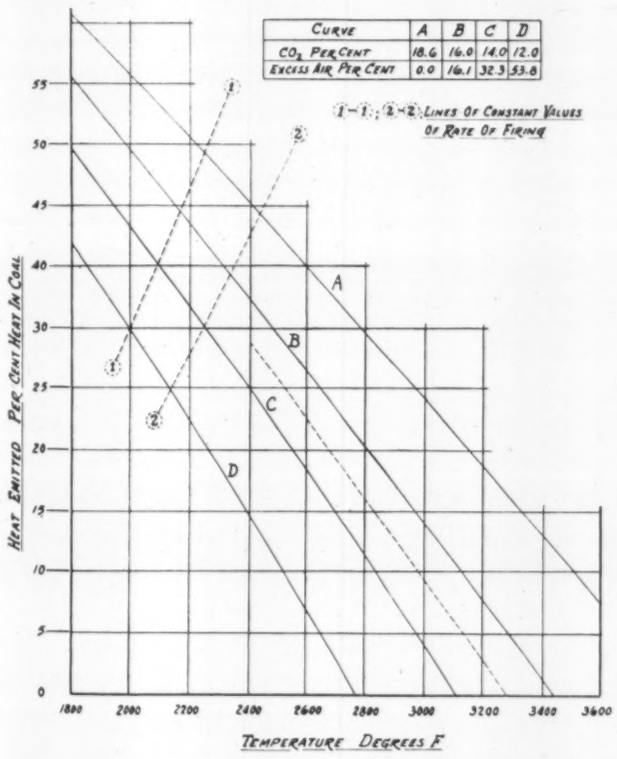
CURVE A B C D
CO2 PER CENT 18.6 16.0 14.0 12.0
EXCESS AIR PER CENT 0.0 16.1 32.3 53.8
1-1; 2-2 LINES OF CONSTANT VALUES OF RATE OF FIRING
A
B
C
D
HEAT EMITTED PER CENT HEAT IN COAL
TEMPERATURE DEGREES F

FIG. 4 HEAT EMITTED, PER CENT HEAT IN COAL TO BRING PRODUCTS OF COMBUSTION TO VARIOUS TEMPERATURES

The presence of coils at the bottom of the furnace of the Oneida Street boiler presented the unique opportunity of measuring the rate of heat absorption in a pulverized-coal furnace. The largest coil had a projected area of 30 sq ft and was constructed of 2-in. pipe spaced apart on about 3-diam centers.

The rate of heat absorption by this coil was of the order of 30,000 Btu per sq ft of total surface per hr, this rate varying very little with the rate of firing, which is contrary to experience with the rate of heat absorption of superheaters placed in the walls of furnaces, where it is almost directly proportional to the rate of firing.

The development of the use of superheaters in pulverized-coal furnaces occurred at the Lakeside plant at Milwaukee, and they have been used in later installations.

The furnaces of the Oneida Street Station installation, like all furnaces at that time, had solid refractory walls. The wasting away of the refractory furnace wall was excessive particularly when the flames impinged against it. Vertical firing caused the least impingement. The ash, collected at the bottom of the furnaces, fused and was difficult to remove while the furnaces were in operation. Studies were, therefore, made to determine to what extent water-cooled surfaces would keep the bottom of the furnace cool and prevent the fusion of the ash. Also, efforts were exerted to devise some means to cool the furnace walls and prevent, or greatly reduce, the wasting away of the refractory lining.

As a result of the studies at the Oneida Street Station, the furnaces at the Lakeside Station were built with air-cooled refractory walls. The air used for combustion was supplied to the furnace through long channels in the walls, thus absorbing some heat from the refractories and lowering their temperature. The air entered the rear wall and flowed through the sides to the front wall where it was distributed by zoned air ports to the furnace.

EVOLUTION OF THE WATER-COOLED FURNACE

One of the furnaces at the Lakeside Station was also equipped with a row of water-cooled tubes over the bottom to keep the ash deposit from fusing and to make its removal easy. This row of tubes was connected into the circulation of the boiler. After a thorough testing of this device, all of the other boilers were equipped with similar water-cooled screens, which was the first step toward water-cooled furnaces.

It was interesting to hear the various predictions of what would happen while the first water-cooled screen was being installed. Some predicted that the tubes would burn up, and others that the cold surfaces in the furnace would hinder combustion and produce black smoke. Neither of these difficulties occurred and the results were very satisfactory, indicating the probability of success of completely water-cooled furnaces. This indication was later fulfilled when the high-pressure boilers with completely water-cooled furnaces were installed at the Lakeside Station. In recent years, the water-cooled furnaces of high-pressure installations have become the main water-evaporating surfaces. The remainder of the boiler evaporates less than 20 per cent of the water.

When the difficulties with the wasting away of the refractories of the furnace wall became very pronounced at higher ratings, it was thought that, if refractories having the correct qualities were used, this wastage could be avoided or at least greatly reduced. A number of high-grade refractories, some of them very expensive, were tested by subjecting them to the pulverized-coal flame. While some of these gave better results than others, none of them could be considered as an entirely satisfactory material for the service. Such refractory tests were repeated by others, apparently with the same conclusions. In most of the present-day pulverized-coal installations, refractories are eliminated as far as possible, and the furnaces are completely water-cooled.

The best rate of combustion in the refractory-lined furnaces of the Oneida Street and Lakeside Stations was between 1 and 1.5 lb of coal per cu ft of furnace volume per hr. The upper limit of the rate of combustion was the slagging of the ash and excessive wasting away of the refractory furnace lining. To minimize these objectionable features, higher excess air was used at the higher ratings. With modern water-cooled furnaces, the rate of combustion is brought up to 2.5 and 3 lb of coal per cu ft of furnace volume per hr. The upper limit is set by the slagging of the boiler and superheater surfaces. This increase in the rate of combustion has been made possible by the development of water-cooled furnaces rather than by an advance in the art of combustion.

While it is true that the combustion in modern water-cooled furnaces is more rapid than in the old-time refractory furnaces, this quicker combustion is obtained by more intensive mixing, made possible by the water-cooled furnaces. Intensive mixing is likely to make the flame sweep over the surfaces of the wall, which would cause rapid wasting of the wall of the refractory furnaces but does not harm the water-cooled walls, provided the inner surfaces of the tubes are kept free from scale.

EFFECT OF FINENESS OF COAL ON COMBUSTION

During the Oneida Street Station tests, investigations were made of the effect of fineness of coal on the completeness of combustion. It was then generally believed that coal to be burned successfully in pulverized form must be pulverized to a fineness of 85 per cent through a 200-mesh screen. The fineness was varied from 64 to 94 per cent through a 200-mesh screen but, at the low rates of combustion made necessary by the refractory furnaces, the effect of the fineness was negligible. The Illinois coal burned at this plant had high volatile-matter content which caused the coarser coal to burn readily. It is well known today that the low-volatile eastern coals give better results when pulverized to a higher degree of fineness.

Investigation was also made of the extent to which coal must be dried in order to be burned successfully in pulverized form. At that time it was thought that the moisture must be reduced to about 1 per cent in order that the coal might be burned successfully. The entire Oneida Street Station was operated with undried Illinois coal for a period of 3 weeks. No appreciable difference in the efficiency of combustion was found. Slight difficulties were encountered in the pulverization and the feeding of the undried coal, but these difficulties were not considered as serious.

During these investigations, it was observed that most if not all of the power used in the pulverization of coal was dissipated as heat, and the temperature rise of the coal and air, the evaporation of some of the moisture in the coal, and the radiation from the mill system accounted practically for all of the power input. The amount of energy absorbed by the process of disintegration of the coal was apparently so small that it could not be measured.

DEVELOPING A SYSTEM FOR DRYING COAL BEFORE PULVERIZING

In those days, the coal was dried in rotary driers which were bulky and expensive, and their use was, therefore, a decided hindrance to development of the use of pulverized coal. Efforts were therefore directed toward the elimination of these driers. Experiments were made with drying in the mills and also drying coal in the bin by passing heated air through the raw coal. Fires which were encountered in these experiments discouraged the use of these methods of drying.

Mill-drying was attempted by heating with steam coils the air returning to the mill in a storage system. This air carried a quantity of very fine coal dust some of which settled on the steam coil and ignited. This fire hazard indicated rather strongly that this was not the correct way to dry coal in the mill. It should be stated here that any air, which is vented from the mill system to remove the moisture, also carries out some of the coal dust which not only is a definite loss, but also forms a nuisance by spreading coal dust on the premises. It was the desire to keep this loss and nuisance very low that led to the experiment of drying the coal by heating the return air with steam coils.

Drying in the mill with hot flue gases in the storage system and with heated air in direct firing was later undertaken and developed to the present state of almost universal application. In the storage system, hot flue gases or hot air are added to the mill system to supply the heat. The same weight of gases or air must be removed from the system in order to carry the moisture out of the mill and to keep the amount of gases circulating in the system constant. The vent losses and nuisance are kept under control in various ways. In the direct-fired system, heated air is supplied to the mill and is all discharged into the furnace with the coal.

Considerable time was devoted to drying of coal by flue gases in a specially designed drier. The coal flowed by gravity through the driers on its way from the raw-coal bunker to the mill, and hot gases were forced through the coal while in the driers. Frequent hanging of the coal in this drier and, at times, fires starting in the hanging coal were very discouraging, particularly when the coal was very fine and wet. This type of drier was sound in principle but the practical difficulties proved so great that its use was abandoned.

SOLVING THE FLY-ASH PROBLEM

The flue dust from the pulverized-coal furnace received considerable attention from those working on the development of the use of pulverized coal as well as from outsiders who worked

(*Continued on page 737*)

WHITHER ENGINEERING EDUCATION?

Report of Special S.P.E.E. Committee[1] on Aims and Scope of Engineering Curricula

I—CURRENT PROBLEMS

FROM its very nature, engineering education operates under changing conditions which constantly challenge its processes and test its results. Its recent history has, therefore, been one of continuing appraisal and adaptation to changing needs.

Continuation of this process of self-examination seems now to be called for by new conditions, trends, and attitudes that will be readily recognized:

(*a*) The thoughtful public has become aware in recent years of the technological nature of our civilization and of the part that engineers must play in the solution of many of its problems. There is, therefore, a widespread insistence that the technological professions should be competent to evaluate the social problems with which they deal and to recognize the social forces which they create.

(*b*) Within the engineering fraternity there is a concerted effort toward a clearer definition of professional status and function coupled with higher qualifying standards and more adequate safeguards for both the practitioner and the public. Among some engineers there is also a desire to reduce the numbers of those preparing for engineering careers.

(*c*) Others would seek rather to secure further recognition of the engineer's vital function, both technical and administrative, in industry and government.

(*d*) Many leaders in education are supporting a movement to make education beyond the secondary school more widely available and to postpone entry upon specialized study until a preliminary period of general study in college has been completed. Particular aspects of this movement are the establishment of many junior colleges in urban and regional centers and the setting up of "general colleges" or junior divisions within universities.

(*e*) Engineering education finds itself confronted also by the rapid and constant advance of science and by the swift changes in technology. New knowledge, new techniques, and new fields of application are pressing for adequate attention in our curricula and the limitations of time which are imposed by a four-year course of study make the resulting problems acute.

(*f*) This elaboration of knowledge and the resulting specialization in college faculties tend to place emphasis on particular items of knowledge at the expense of fundamental relationships. Many engineering educators are therefore seeking ways of increasing thoroughness and breadth of instruction in fundamental matters and of stimulating among students initiative, resourcefulness, and originality.

In the light of these conditions and attitudes we believe that the engineering colleges will desire at this time to examine anew their functions as institutions of higher education, to reconsider the selection and grouping of their materials of instruction, and to weigh without prejudice the duration and character of the formal training needed to prepare engineers for their careers, whether in more highly professional capacities or in other technical and administrative service of industry and government.

II—CONTROLLING FACTORS

The institutions in which engineering is taught include universities of complex organization, land-grant colleges, privately endowed and publicly supported institutes of technology, colleges with associated curricula in liberal arts and in engineering, and junior colleges which offer the first two years of engineering. Despite this diversity in organization, there is among engineering colleges a basic uniformity of aims, ideals, methods, and standards of undergraduate instruction. This homogeneity is not the result of any imposed standardization; it is derived from a strong sense of solidarity among the different institutions and from the common ends they serve. In these circumstances there is ample opportunity for well-considered variations in curricula and for educational experimentation.

Within the broad realm of technology are functions which are highly diverse and exist on many levels of responsi-

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[1] The appointment of this committee was authorized at a joint meeting of the council and institutional delegates [of the Society for the Promotion of Engineering Education] held during the annual convention of June, 1939. The occasion for its appointment was the discussion, which had been active for some time, of the need of extending the period of undergraduate curricula to five or six years. There was active discussion also of the desirability of a preliminary period of study in schools of liberal arts before admission to the engineering school. A bill had recently been introduced in the legislature of the State of New York intended to promote this practice by giving credit for such educational experience to those applying for professional licensure.

The committee was instructed to examine the various aspects of this matter and to present a report at an informal meeting of members of the society to be held at Washington during November. A preliminary report was therefore prepared for discussion by those present at the meeting. Other members of the society, engineers in practice, and educational leaders were invited to submit criticism and suggestions, and copies of the report were sent to presidents and deans of institutions offering engineering curricula. The present report has been prepared, therefore, as a result not only of the deliberations of the committee but in the light of expressions of the views of many others.

In directing its attention to the matter of the length of the curriculum, the committee has naturally and of necessity considered the broader aspects of engineering education which bear upon the specific problem and presents its report as one dealing in general with the aims and scope of engineering curricula.

The committee has held two meetings, one of three days' duration. A subcommittee has also held several meetings to edit drafts of the report prepared at general meetings of the committee. These drafts have then been circulated and re-edited. During the concluding stages of this process the committee has enlisted the cooperation of J. R. Killian, Jr., of the Massachusetts Institute of Technology.

The committee comprises the following members: J. W. Barker, F. L. Bishop, E. S. Burdell, G. M. Butler, I. C. Crawford, R. E. Doherty, H. J. Gilkey, W. O. Hotchkiss, E. L. Moreland, W. E. Wickenden, H. E. Wessman, and H. P. Hammond, chairman.

While approving much of the material in the report, Dean Butler dissents from the view that a satisfactory professional engineering curriculum can be provided in four undergraduate years.

bility. Some of them are in a high degree professional, others are subprofessional or nonprofessional in nature; some are scarcely to be distinguished from pure research, while others verge on commerce or finance. Diversity is, in fact, one of the basic characteristics of engineering services.

While the activities of engineers have a common denominator in the engineering method they are too numerous and varied to fall within any definition of a profession that could be legally defended and applied. These responsibilities include the entire range of technical and executive direction involved in the production of fuels and industrial materials, the planning and erection of structures, the design and fabrication of industrial products, the planning and operation of utility services, the ordering of industrial plants and processes, the sale of technical products and their adaptation to special uses, and the administration of technical enterprises, both private and public. The education of men for all these activities lies within the responsibility of the engineering college.

Since the *engineering profession* clearly cannot isolate itself from this complex of men and functions as a well-defined caste, it may be said to exist as a vaguely bounded nucleus within a much larger enveloping group which we may call the *engineering fraternity*. While progress is being made in defining the boundaries and standards of this professional nucleus and in giving it legal status through state registration, diversity of practice and fluidity of organization still remain distinguishing characteristics of engineering groups.

In the conduct of engineering education the colleges are associated with an important group of professional societies, some primarily technical and some concerned mainly with professional status. They are associated also with state licensing boards, with industrial interests, and with agencies of government concerned not only with education but also with social welfare, scientific research, the regulation of industry, and the direction of public works.

These many-sided relationships and the diverse activities of engineers have had a determining influence on engineering colleges and their programs. These institutions should not be considered as professional schools in the exclusive sense as are the schools of law, medicine, and theology. Rather, they constitute one of the major functional branches of the national system of higher education; the technological branch as distinct from agriculture, commerce, journalism, education, and the like. For the most part engineering colleges have given their students a sound, general education distinctive in type and useful in a wide range of occupations. They have emphasized professional responsibilities and ideals more than other colleges of a general functional type, and this emphasis has contributed to the coherence of their work, but few have made preparation for strictly professional practice their predominating objective.

The varied activities and responsibilities demanded of engineers have had another important result. For many years engineering schools devoted themselves almost wholly to instruction on an undergraduate level, but in recent years a large number of them have extended their teaching and research to include the entire range of undergraduate and postgraduate activity.

Students served by engineering colleges for the most part are young men who have been drawn at a relatively early age by the appeal of applied science. Some of them have been influenced by the favorable placement of engineering graduates or by the fact that they can be prepared for self-support in four years. Many of these students are the unsifted products of the secondary schools except as early fixation of interest and the distinctive entrance requirements of some engineering schools serve as selective influences. Because of the popular appeal of the college degree and the unfortunate lack of recognition of excellent types of institutions other than the degree-granting college many students enter engineering colleges who would have better prospects of success in institutions offering a briefer and more practical type of program.

Among those who are well qualified for college, the motivation of practical interest is usually strong, but a definitely intellectual interest often needs to be awakened and nourished in college if it is to survive after graduation. The purpose to follow a career in the more highly technical aspects of engineering or to seek one in the commercial or executive ranks of industry usually remains only partly formed until graduation approaches. A substantial and increasing proportion of those who decide upon a career in technical engineering continue as advanced students, although often on a part-time basis and not infrequently through training programs which are offered by industry.

Guiding their students in a progressive choice of career aims is one of the major responsibilities of an engineering college. While it would be to their great advantage to divert many applicants to other types of institutions and to select their students with greater discrimination, proposals which might lead to a break in the continuity of the guidance process in the college period ought to be examined with critical care.

III—GENERAL POLICY

In considering the trends and attitudes outlined in section I and the conditions affecting the conduct of engineering education described in section II it seems clear that the problems of the engineering colleges might be simplified by restricting their function to the training of men for the higher professional levels. It must be borne in mind, however, that at present engineering colleges constitute almost the sole agency for preparing young men for technological pursuits. For the common good, therefore, technological education must be kept widely available, its admission requirements should correspond to present needs and interests of young men, and its terminal points should conform to the varied needs of industry and the public service as well as to the standards of admission to the engineering profession. Until other types of institutions are established in sufficient numbers to assume a significant part of the burden, satisfaction of these needs must continue to be the duty of the engineering colleges. Moreover, it is an obligation clearly to be recognized in the constitution of many of our institutions, including the large group of land-grant colleges which were established to diffuse scientific knowledge among the industrial classes rather than to canalize it in strictly professional channels.

In view of their broad function and their complex relationships, we consider it neither feasible nor socially desirable for the present group of engineering colleges to limit their aim to the preparation of young men for professional registration and practice. Neither do we see any reasonable means of dividing these colleges into two groups, one to include only professional schools in a strict sense and the other to comprise more general schools of industrial technology.

In addition to providing the elements of a widely useful general education the engineering colleges should specifically provide: (1) A professional discipline in the several branches of engineering; and (2) preparation for numerous executive, commercial, and service functions in technical industries and public agencies which are not strictly professional in character, although of comparable responsibility. These two fields require nearly identical foundation training with a broad scientific and social base and adequate grounding in engineering methods of analysis and application. The higher and more specialized forms of technical training are essential only in professional

activity, and cannot be provided adequately in undergraduate curricula alone.

We are encouraged by recent evolutionary trends, which include a broadening of undergraduate curricula and a pronounced increase in graduate work, to believe that the ends suggested in section I can be obtained by further changes in the selection and grouping of studies and improvements in methods of instruction, by better selective processes of admission, and by further development of graduate work where more specialized or advanced training is desirable. Furthermore, we believe that constantly changing needs can be better met within the present framework of undergraduate and postgraduate studies in the colleges and of advanced training programs provided by industry than they can through a program uniformly extended for all engineering students.

While we believe that the broad aims which have characterized engineering education should be preserved, a clearer definition of its scope seems highly desirable. Engineering education rests on a foundation of science, of humanities, and of social relationships rather than on the practical techniques of particular occupations or industries. Training in such practical techniques should require less than four years. Moreover occupational demands which might be served by training of this type are potentially much larger than those requiring an engineering degree. Since few schools of this kind now exist above the secondary level their number should be greatly increased in order to broaden the opportunity for technical education. Greater recognition, furthermore, should be given to these institutes in order that their importance in our educational structure may be appreciated and understood. A highly desirable result of such a development would be to open new paths of success and placement to many young men of good abilities, but with practical rather than scientific interests, who now enter the engineering colleges with a resulting disadvantage to themselves and to the colleges.

Considering only those young people to whom the education given by an engineering college is well adapted, we believe that their needs cannot properly be met by a program of uniform length, although we are convinced that the course leading to the bachelor's degree conforms well to the interest and career requirements of a large proportion of these students. For many of this group graduation represents a genuine limit of time and of means available for formal education; for many it represents also a scholastic attainment satisfying their tastes and native endowments. Moreover, this level of attainment conforms well to the personnel requirements of many service functions in industry, in engineering organizations, and in government agencies. We believe the imposition of a longer college program on all engineering students through a prescribed five- or six-year course would be inconsistent with the financial resources, career needs, and abilities of many of this large group.

Preparation for the higher technical levels of engineering is unquestionably a duty of the engineering colleges. Such preparation clearly requires more than a four-year period and should extend beyond the baccalaureate degree. Provision for postgraduate education is necessary, furthermore, if adequate time is to be allowed in the undergraduate period for thorough grounding in the basic sciences, for laying the foundations of a social philosophy, for developing powers of effective expression, and for cultivating reflective and critical habits of thought. If the undergraduate period is concentrated chiefly on these objectives, and if, at the same time, an adequate introduction is given to engineering methods of applying science to actual problems, the value of the four-year program, we believe, will be enhanced. To attain these objectives will require the transfer of some of the more advanced subject matter to the post-baccalaureate period where it may be pursued with a rigor consistent with adequate preparation for engineering specialization.

The individual's need of this advanced training is not always evident to him before graduation; frequently it cannot be discovered and defined until the individual has had some exploratory experience in practice. We believe a natural process of selection operating through individual experience in this transition from undergraduate to advanced study is a more desirable means of limiting the higher ranks of professional engineering than is the imposition of a uniformly lengthened program of studies.

We believe that the foregoing suggested rearrangement of program and change of emphasis not only would make for thoroughness and breadth in fundamental studies, without sacrifice of the motivation which springs from youthful interest in applied science, but also would encourage greater resourcefulness, imagination, and self-development among engineering students.

We believe that there are advantages in the parallel development of the *scientific-technological* and the *humanistic-social* sequences of engineering education. When the elements of these sequences are compartmentalized and taught at different stages of the curriculum, they frequently remain unrelated and uncoordinated in the student's mind. Furthermore, a continuous development of the humanistic-social sequence prevents its complete relegation to the less mature stages of the student's career when it cannot be so effectively presented and when the student has an inadequate understanding of its importance and its bearing upon his scientific-technological studies.

We favor an integrated program of study extending through the entire undergraduate period rather than a division into separate stages. This program should be so planned, furthermore, that it may be articulated with specialized postgraduate programs.

For a minority of the students with time and money available for a period of undergraduate education extending over five years or more, we recognize that there may be advantages in a program of study in a college of liberal arts followed by work in a college of engineering. The chief advantage to be gained from this combined program is often intangible, and resides in the experience of life and work in two diverse types of institutions quite as much as it does in any wider range of instruction.

The engineering colleges in some circumstances must coordinate their programs with those of detached junior colleges or of general colleges covering the first two years of undergraduate study in universities. This arrangement usually necessitates more than four years of study for a degree in engineering. It also involves a sacrifice in the coordination of scientific, technological, humanistic, and social studies present in well-planned four-year engineering-college curricula. This observation does not apply with equal force, of course, to students who transfer from those junior colleges which duplicate the engineering curriculum of the first two years of the senior institutions.

IV—OBJECTIVES OF THE PROPOSED POLICIES

Certain phases of the general policy here outlined, especially those dealing directly with undergraduate curricula, require further definition and emphasis. The committee wishes to make clear that it cannot envisage at this time all the detailed measures which may be necessary to put its recommendations into effect. It is able to indicate them only in outline and without the weight of specific proposals.

First, broadening of the base of engineering education, now in process, should be continued. Its roots should extend more deeply into the social sciences and humanities as well as into

the physical sciences in order to sustain a rounded educational growth which will continue into professional life. Two stems are thus implied in the undergraduate curriculum which we have designated as the scientific-technological and the humanistic-social. Each of these should be organized in an articulated sequence of subject matter and disciplines designed to lead to definite educational objectives.

The scientific-technological studies should be directed toward:

1 Mastery of the fundamental scientific principles and a command of basic knowledge underlying the branch of engineering which the student is pursuing. This implies:

(*a*) Grasp of the meaning of physical and mathematical laws, and knowledge of how they were evolved and of the limitations in their use

(*b*) Knowledge of materials, machines, and structures.

2 Thorough understanding of the engineering method and elementary competence in its application. This requires:

(*a*) Comprehension of the interacting elements in situations which are to be analyzed

(*b*) Ability to think straight in the application of fundamental principles to new problems

(*c*) Reasonable skill in making approximations, and in choosing the type of approach in the light of the accuracy required and the time available for solution—in sum, a foundation for engineering judgment

(*d*) Resourcefulness and originality in devising means to an end

(*e*) Understanding of the element of cost in engineering and the ability to deal with this factor just as competently as with technological factors.

3 Ability to select the significant results of an engineering study and to present them clearly and concisely by verbal and graphic means.

4 Stimulation of a continuing interest in further professional development.

The humanistic-social studies should be directed toward:

1 Understanding of the evolution of the social organization within which we live and of the influence of science and engineering on its development.

2 Ability to recognize and to make a critical analysis of a problem involving social and economic elements, to arrive at an intelligent opinion about it, and to read with discrimination and purpose toward these ends.

3 Ability to organize thoughts logically and to express them lucidly and convincingly both in oral and written English.

4 Acquaintance with some of the great masterpieces of literature and an understanding of their setting in and influence upon civilization.

5 Development of moral, ethical, and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare, and to a sound professional attitude.

6 Attainment of an interest and pleasure in these pursuits and thus of an inspiration to continued study.

Second, to attain the ends indicated by the foregoing general policy requires high efficiency in use of the limited time available to the student. Attainment of this efficiency means further reduction of the total content of required subject matter and concentration on fewer courses pursued simultaneously; it means minimizing purely descriptive material and repetitive tasks; it means the abandonment of effort to develop of the specialized skills that are now emphasized. It means, in brief, a process of pruning to the essentials of a sound educational content in the interest of the mastery of those essentials.

Such a process of pruning, however, does not mean the weakening but rather the strengthening of the undergraduate program as a preparation for subsequent professional development. Greater concentration of effort upon the mastery of fundamental concepts and the cultivation of intellectual powers required in the more advanced use of the engineering method would provide a more effective base for advanced scientific study, render the graduate more sensitive to the lessons of practical experience, and thus prepare him effectively for subsequent professional development.

To weaken the educational base of professional study would, of course, defeat our entire purpose. The fact must always be held in view that, while we regard the humanistic-social element as fundamental and vital to the engineering curriculum and feel that its importance must be more adequately recognized and its aims more clearly defined than they usually are at present, engineering science and method constitute, by definition, the dominant interest in the curriculum and so must be accorded the dominant portion of time. Otherwise the curriculum would no longer be within the scope of engineering education.

And finally, we reaffirm the belief that under the diverse conditions that surround and permeate engineering education no single plan as to length and nature of the curriculum applicable, alike to all institutions, is either practicable or desirable. On the contrary we believe that the variety of conditions that will always pertain to science and technology require diversity rather than enforced uniformity in the educational process; and we believe especially that there should be freedom for experimentation and change in education just as there is in the world which it serves.

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Engineering colleges serve diverse functions and prepare men for a wide range of technical, administrative, and executive responsibilities. Technological education should, therefore, be kept widely available, and engineering colleges must continue to serve a correspondingly wide variety of purposes. They should not limit their aim to preparing young men for professional registration and practice.

The present flexible arrangement of four-year undergraduate curricula followed by postgraduate work will better meet the needs served by engineering education than will longer undergraduate curricula of uniformly prescribed duration.

Engineering colleges could operate more effectively if briefer and more directly practical forms of technological education were provided by other types of institutions.

Advanced training for the higher technical levels of engineering should be included in the general program of engineering education but should not become its dominating aim.

Undergraduate curricula should be made broader and more fundamental through increased emphasis on basic sciences and humanistic and social studies. This will require greater efficiency in the use of the student's time to be gained by pruning to the essentials of a sound educational program.

Some of the advanced technical subject matter now included in undergraduate curricula should be transferred to the postgraduate period where it may be pursued with a rigor consistent with preparation for engineering specialization.

There are advantages in the parallel development of the scientific-technological and the humanistic-social sequences of engineering curricula. The present integrated type of program extending throughout the entire undergraduate period should therefore be preserved.

No measures taken with respect to engineering education should limit the freedom that now exists for experimentation and change.

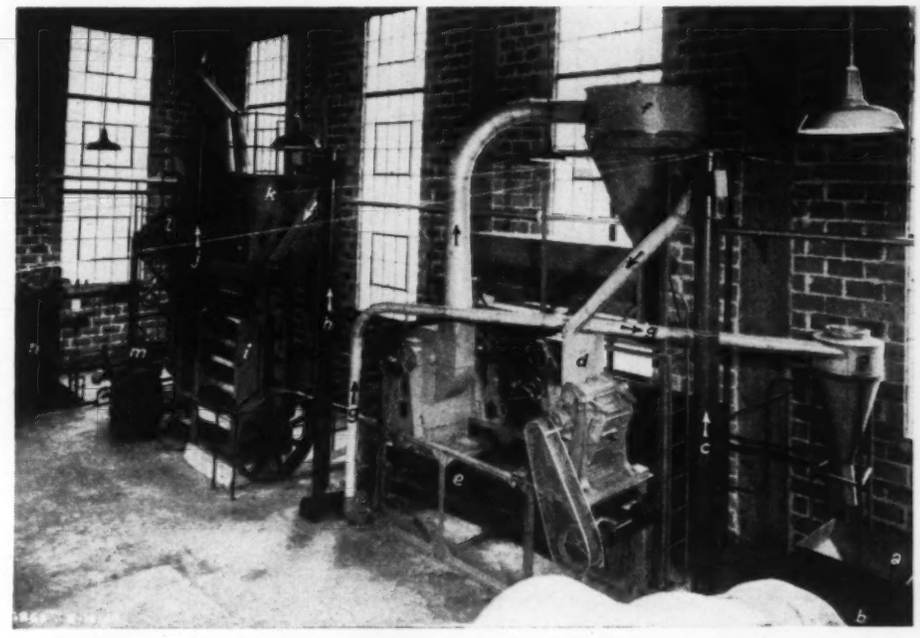

FIG. 1 COTTONSEED PILOT PLANT AT ENGINEERING EXPERIMENT STATION, UNIVERSITY OF TENNESSEE

(*a* = Hopper into which seeds are fed; *b* = humidifier; *c* = elevator; *d* = huller; *e* = shaker and separator; *f* = receiver for hulls; *g* = rejected seed returned to feed hopper; *h* = elevator; *i* = crushing rolls; *j* = elevator; *k* = storage hopper; *l* = pressure cooker; *m* = cake former; *n* = press.)

COTTONSEED PRESSURE-COOKING RESEARCH

By ROSCOE W. MORTON[1]

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COTTONSEED processing research was started at the University of Tennessee early in 1929 by Dean W. R. Woolrich, at present of the University of Texas, at the request of the Tri-States Cotton Seed Oil Mill Superintendents Association.

In 1932 a special research committee on cottonseed processing was established by The American Society of Mechanical Engineers and a grant of some $500 from the Engineering Foundation was obtained for the first contribution of the Society toward the research in this field. Dean Woolrich, as chairman of this A.S.M.E. committee, has reported on the history and early part of this work.[2] As the research project progressed, the T.V.A. became interested in it and contributed to it, but it was the early work carried on under the grants of A.S.M.E. that actually opened up the field of research in the mechanical processing of cottonseed.

Since the progress report of last year, the new quarters of the Engineering Experiment Station at the University of Tennessee, in which the cottonseed research project is being conducted, have been equipped and are now in operation. This station is under the direction of C. A. Perkins, director, R. Brooks Taylor, and John F. Leahy.

PILOT-PLANT PROCESSING EQUIPMENT

The cottonseed processing equipment installed in the station, shown in Fig. 1, constitutes a pilot-size continuous plant where the laboratory studies can be adapted to plant scale of operation.

A flow diagram of the cottonseed processing operation, prepared by Mellon Institute, is reproduced in Fig. 2. Referring

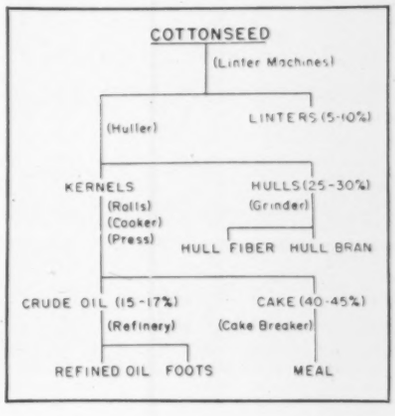

FIG. 2 FLOW SHEET OF COTTONSEED PRODUCTS

(Parenthetical figures represent approximate yields of each end product. Prepared by Mellon Institute, *Chemical Engineering News*, vol. 18, no. 4, Feb. 25, 1940, p. 139.)

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[1] Chairman, Vegetable Oils Committee, A.S.M.E. Process Industries Division; Professor of Mechanical Engineering, University of Tennessee.

[2] "Cottonseed Processing Research," by W. R. Woolrich, MECHANICAL ENGINEERING, vol. 61, no. 2, 1939, pp. 131–135.

Contributed by the Process Industries Division and presented at the Semi-Annual Meeting, Milwaukee, Wis., June 17–20, 1940, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Slightly abridged.

FIG. 3 TWO HUMIDIFIERS, SMALL ONE ON RIGHT AND LARGE ONE ON LEFT (ON SKIDS)

to Fig. 1 the feed hopper on the right receives the seeds which pass through the humidifier, Fig. 3, which is an important part of the equipment used to condition the seed to provide a constant moisture content of the raw material. The seeds then pass to the elevator and thence to the huller, shaker, and separator, Fig. 4, where the hulls are separated and sent to the cyclone receiver above the huller. The meats are elevated and fed to the rolls, and are then elevated again to the storage hopper above the rolls or to the pressure cooker on the left. As the meats come from the cooker they are fed to the cake former immediately below the cooker and are then placed in the hydraulic press shown at the extreme left of Fig. 1 and in the center of Fig. 5. The pumps for these presses are on the left. The cake cloths (some are shown on the horse at the lower right-hand corner of Fig. 5) provide the filter medium for the oil as it is expressed in the hydraulic presses to be seen in the center of the same illustration.

A small batch pressure cooker, Fig. 6, is used to run controls on the pilot plant and to help adapt laboratory technique to the pilot-plant scale. An agitator is provided to insure uniformity of product and to keep the meats from being burned.

The pilot plant just described is based upon only one of the types of process equipment in use today, the hydraulic-press type. In addition the expeller and the solvent extraction processes are in use. A laboratory expeller is shown in Fig. 7.

A complete control laboratory, shown in Figs. 8 and 9, is also maintained so that accurate analyses may be made not only for the work of the Engineering Experiment Station but for the industry as well.

NATURE OF THE 1940 RESEARCH PROGRAM

The research in cottonseed processing during the current year has been a further investigation of possible application of the pressure cooker as a nucleus of any one or all three of the common oil-recovery processes. Present practice imposes preliminary processing methods peculiarly suited to the established requirements of the oil-recovery process used and such methods are usually not interchangeable in the hydraulic-press, the expeller, and the solvent processes. The hydraulic-press method is usually identified with the processing of cottonseed and the expeller method with the processing of soybeans, while the solvent process has been applied, to a very limited extent and with indifferent success, as a universal system.

It is desirable that a method of mechanical processing be evolved which will permit the efficient use of all three of these recovery methods with all commercial raw materials. During the last year experiments have been made in expressing peanut oil, linseed oil, and soybean oil, in addition to cottonseed oil. Because of the limitations of the processing machinery, the experiments have been conducted with the hydraulic-press equip-

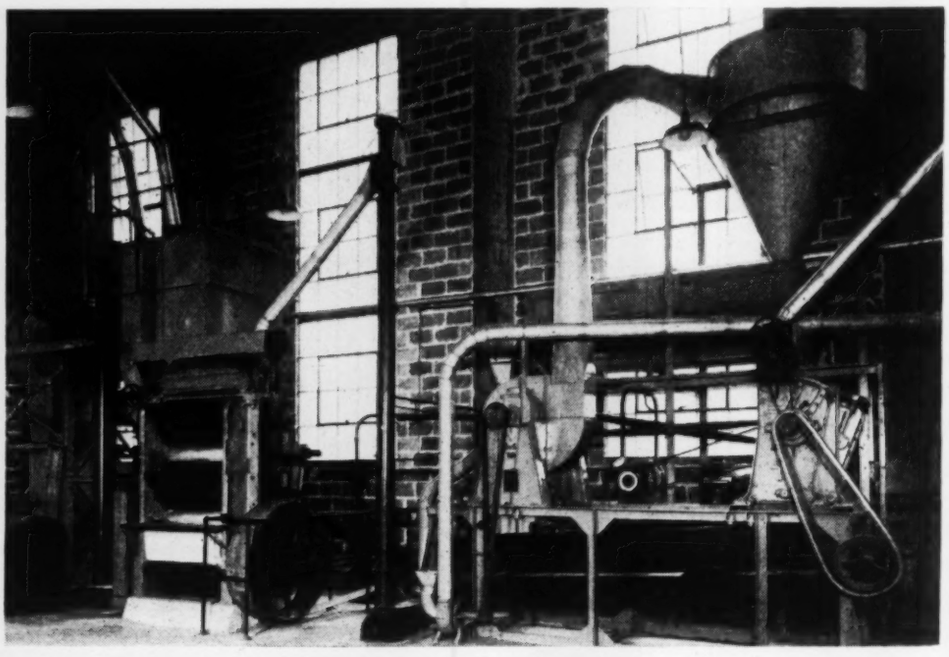


FIG. 4 ANOTHER VIEW OF PILOT PLANT
(Huller, shaker, and separator at right; crushing rolls at left center; pressure cooker and cake former at extreme left.)

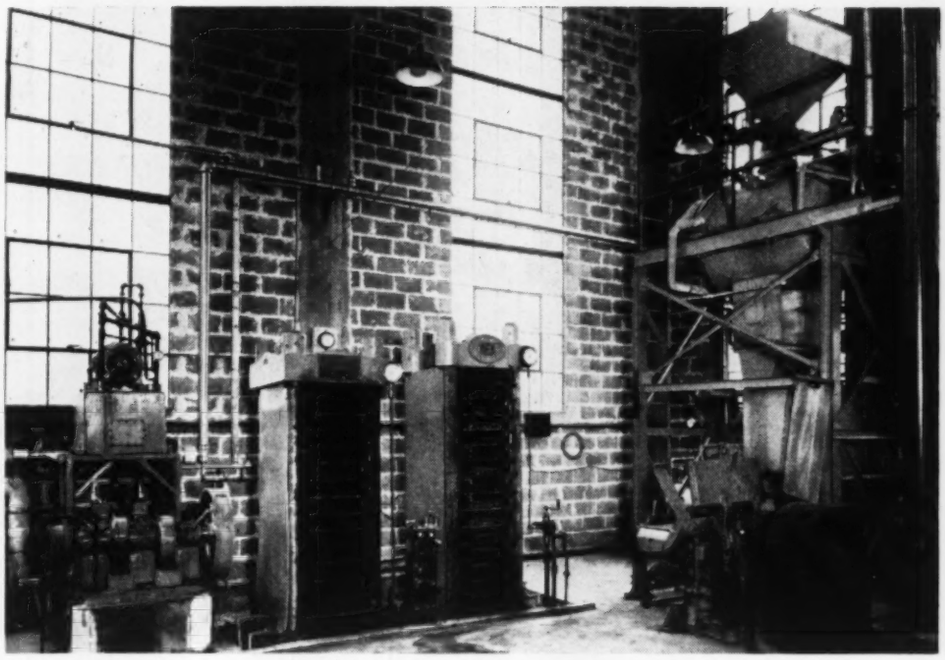


FIG. 5 HYDRAULIC PRESSES AND THEIR CONTROL VALVES
(Two hydraulic pumps, Vickers above and Davidson-Kennedy below, at left; pressure cooker and cake former below it at right.)

ment with the object of investigating the practicability of processing materials other than cottonseed in existing cottonseed-crushing plants in which the hydraulic-press process of oil recovery now predominates.

Field operations have been conducted in the processing of seriously "field-damaged" cottonseed in the plants at Macon, Ga., and Greenwood, Miss., where pressure cookers are installed.

Three companies are now licensed to build the cookers developed at the Experiment Station.

PROBLEM OF PRESSURE-COOKER CONTROL

Early in the development work it was recognized that the pressure-cooker design presents possibilities in control not heretofore available, because a totally enclosed vessel is used. One problem that arose is of interest. If the meats are heated under pressure until the temperature corresponding to that of saturated steam at the same pressure is reached, the temperature line on the chart of the recording thermometer should remain constant for at least the short period of time in which the moisture present in the meats is driven off. It was hoped that this constant temperature-time portion of the chart could be used to govern the cooking cycle. It was found, however, that this condition does not exist and it is suspected that some of the volatile constituents of the oil are distilled early and thus the oil and moisture mixture in the cooker gives rise to a varying temperature distillation curve. Recently, a positive control has been worked out with the Bristol Company, which should furnish accurate control of this cooking operation. With the manual operation controlled cooking was limited to a function of temperature and time, but with the automatic controls the moisture present in the meats is also involved.

Studies and designs are now under way for the development of a continuous pressure cooker for use with the expeller type of oil-recovery equipment. Even though the present batch cooker can be used with the expeller, a continuous cooker will prove much more satisfactory and can also be used with the solvent recovery process.

EXPERIMENTS WITH EXPELLER PROCESS

The expeller is a desirable method of oil recovery from the standpoint of labor and continuous operation. Difficulty has arisen, however, because of the peculiar characteristic of the products obtained by this method. In certain localities it has been found profitable, from the financial standpoint, to use the established method, notwithstanding the lower grade of product so produced, due to local conditions that afford a ready market for such products. It is acknowledged that improvements in results can be obtained with the continuous pressure cooker so that the grade of product will compete favorably with that obtained with the press type of extraction. Laboratory experiments indicated, and plant experience confirmed, that this is feasible. A new mill is being built at Marks, Miss., using the expeller type of extraction with pressure cooking. Several mills have been remodeled and field experiments show that the favorable laboratory results can be duplicated in commercial plant practice.

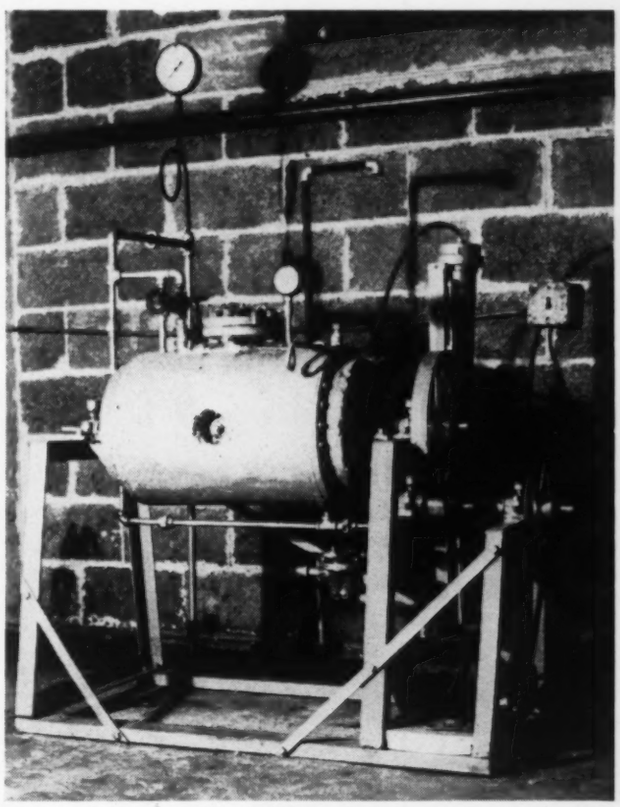


FIG. 6 SMALL BATCH PRESSURE COOKER

EXPERIMENTS WITH HYDRAULIC PRESS SYSTEMS

A development of interest to mechanical engineers is the means for applying pressure at the press. It has been found that the manner of applying pressure has an important bearing on efficiency of oil extraction and also upon economy in the use of the cloth that covers the cake. Most of the hydraulic systems at present require accumulators to provide the necessary control of the oil used to actuate the presses. The difficulty of keeping the oil clean so that it would not contaminate and clog the choker or automatic change valves made this part of the cycle costly. A small Vickers pump is now used to provide a pressure of 500 psi to operate the valve, to take up the slack of the press, and for other services, while a Davidson-Kennedy pump is used to provide the high press pressures.

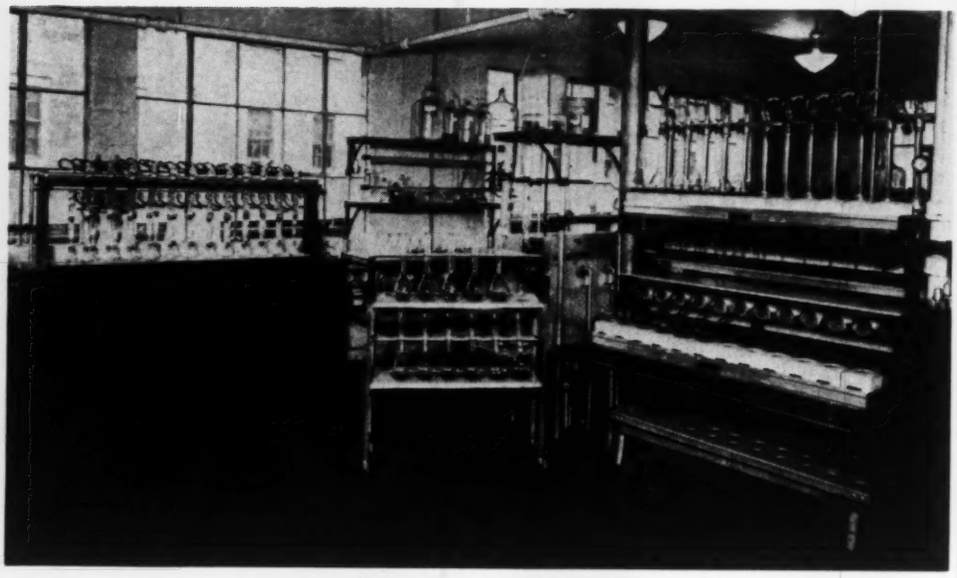


FIG. 8 A VIEW OF THE CONTROL LABORATORY

The high-pressure yielding plunger pump now used has proved to be a decided improvement as it eliminates delicate controls. The pump can be made to apply the pressure in a manner which gives a greater efficiency in oil extraction and a saving in press cloth. The pump is of the plunger type, but preloaded springs are placed between the driving crosshead and the plunger. These springs will not act until the pressure has reached approximately 1800 psi. The take-up and preloading curve with respect to time is rather steep. After this pressure is reached the stroke of the plungers is gradually reduced with each revolution until the maximum pressure is reached, at which time the effective stroke of the plunger is zero. This maximum pressure can be maintained as long as desired. The curve of pressure increase versus time for the range between 1800 psi and about 5000 psi has a more gradual slope than the preloading curve. The slopes of both curves can be decreased by changing the speed of the drive shaft, that is, the time to reach the maximum pressure can be increased. The maximum pressure at which the curve levels off can be controlled by adjusting lock nuts that control the spring pressure.

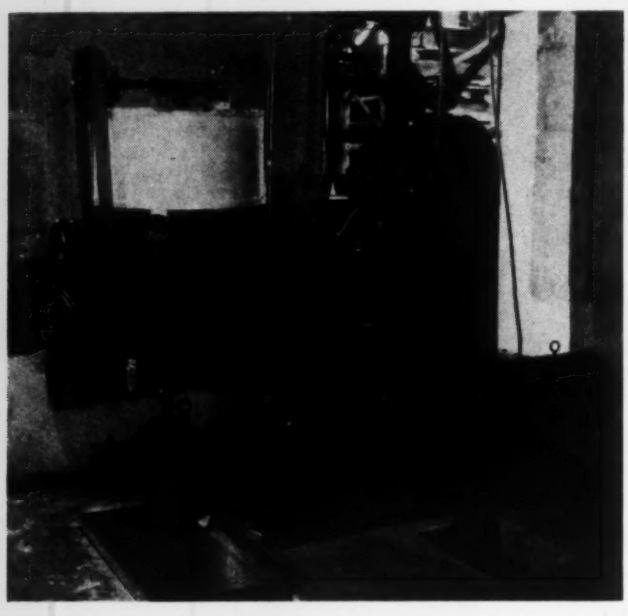


FIG. 7 LABORATORY EXPELLER UNIT

PLASTICS DEVELOPED AS A BY-PRODUCT

Research in the field of pressure-cooker design and operation, initiated by mechanical engineers, has materially changed the procedure in many cottonseed-oil plants and it is reasonable to expect that further work will have even a more far-reaching effect. As a result, chemists and chemical engineers have become interested in the possibilities of the materials made available by the extraction of cottonseed oil. We have now developed a plastic that is of interest because of its structural, insulation, and dielectric properties. This plastic is made of the cottonseed hulls which comprise the cheapest by-product of the oil mill. The plastic compound contains 60 per cent of cotton hulls when used for regular plastic, 85 per cent when used for tile, and 95 per cent when used for wallboard. The relatively large quantity of hull filler used greatly reduces the amount of chemical binder necessary, and this fact should materially reduce the cost of production of the finished plastic. The plastic is of the thermosetting type. Products are formed at a pressure of 3000 psi and a temperature of 310 F in $1^1/_2$ min and no other treatment is necessary. This rapid setting should materially increase the production per mold which again should decrease the production cost per part pressed. The thermal conductivity K of this plastic is $1.18 + 0.0004(\Delta T)$ Btu per deg F temperature difference per sq ft per hr per in. of thickness. This value compares favorably with similar types of board construction, and in view of the fact that the plastic takes an excellent surface finish it should find its place of service.

OTHER BY-PRODUCTS

Something like 1,000,000 tons of cottonseed hulls are produced annually as a by-product of the oil mills. Some of these hulls are used as a filler for mixed feeds, for which purpose they bring about four dollars per ton. When the price is below four dollars oil mills frequently burn the hulls instead of coal. A steady outlet for the hulls would materially aid the oil industry. Plastics might provide such an outlet. More recent research

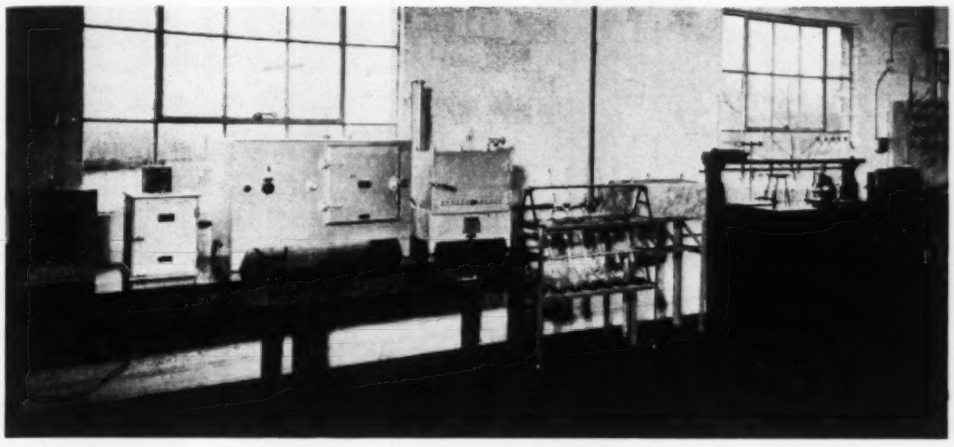


FIG. 9 ANOTHER VIEW OF CONTROL LABORATORY

indicates that furfural production might add to this outlet and still further increase the amount of cottonseed hulls in the plastic.

Furfural is now obtained commercially from oat hulls, but cottonseed hulls are richer in furfural-forming pentosans; also the quantity of cottonseed hulls available is about $3^1/_2$ times that of oat hulls. The residue from oat hulls is burnt or charred after extraction, while that from cottonseed hulls is not, and a process is anticipated which will use this residue as a source of lignin for lignin-plastic production.

Furfural can be prepared from cottonseed hulls by extracting furfural-yielding substances by means of a dilute acid solution and heating the resulting solution under pressure to form furfural.

STUDIES IN DECORTICATION PROPOSED

Another mechanical operation that has presented itself as a result of early studies is decortication and separation of the hulls and the meats. A request has been presented to the Engineering Foundation for a grant to finance a project on this subject. The objective of the project is the evolution of a novel processing method whereby nearly pure cottonseed meats may be obtained for subsequent processing to recover oil and protein-bearing cake residue.

The prior art processes contemplate decortication following delinting by mechanical methods. The delinting of cottonseed is a necessary process in preparation for decortication by such existing methods, and the delinting process resulted from this need. Since the evolution of the existing process wherein the delinting performance influences the efficiency of the hulling or decortication operation, the by-product of the delinting operation, cotton linters, has become increasingly valuable. Originally, some fifty pounds of cotton linters were recovered from each ton of cottonseed processed, while the present practice contemplates linters recovery in the amount of 200 lb per ton of cottonseed.

The substantially increased production of cotton linters, while contributing to the efficiency of the actual decorticating operation, adversely influences the efficiency of the separating operation wherein the cottonseed kernels are separated from the hulls. Heretofore, the residual lint with the hulls formed a mat on the oscillating screen used in effecting the desired separation. The absence of residual lint with the hulls introduces the difficulty of forming such a mat and as a result an appreciable quantity of fine hull particles pass through the screen with the meats, making it difficult to maintain the desired protein concentration in the residual cake or meal, the ultimate product of the complete process.

Research study and preliminary laboratory investigations have revealed the possibility of the successful decortication of cottonseed, either in the linted or delinted state, by means of steam explosions similar in some respects to the process employed in "puffing" wheat and rice kernels. It is probable that decortication and separation may thus be accomplished simultaneously, permitting the recovery of whole cottonseed kernels relatively free from hull contamination and hence the manufacture of cottonseed cake of 50 per cent protein concentration.

It is now proposed to embody the principles and possibilities discovered by research and experimentation with plant equipment in order to develop the process further, and design suitable machinery to make use of such a process in the cottonseed-crushing industry.

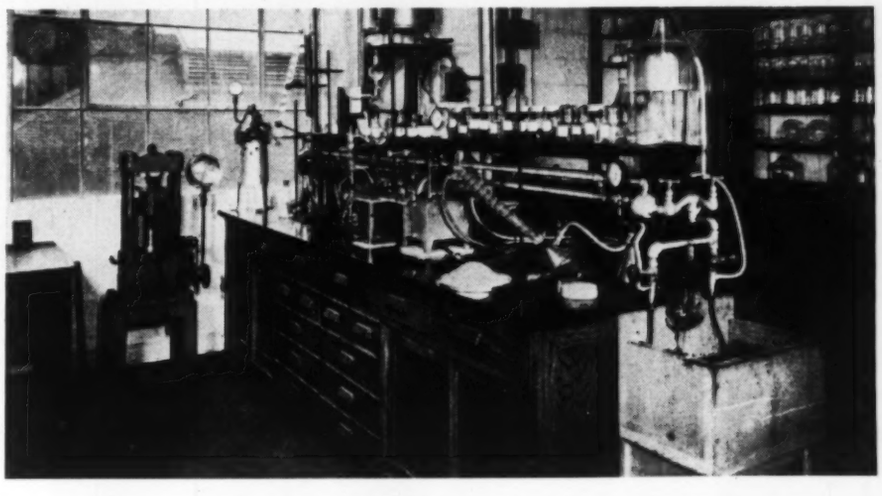


FIG. 10 A VIEW OF THE EXPERIMENTAL LABORATORY

GOVERNMENT AND ECONOMIC LIFE[1]

By B. ALDEN THRESHER

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PHILOSOPHERS in all ages have found among the social insects analogies for the economic as well as the moral aspects of human society. These remain today as serviceable as ever. In the relations of the beekeeper to the hive of bees is found an apt illustration of the relation of government to economic life in a society of free enterprise.

Bees function under their own initiative, driven by an energy lying within themselves, toward ends which it is their nature to seek, and utilizing such food resources as lie within their reach. The task of the keeper can be regarded partly as implementation and furtherance of the spontaneous efforts of the colony, partly as regulation and control of its natural energies. Supplementary food is provided for the immature insects; wooden frames at once aid in the formation of the combs and confine their shape; swarming is watched and controlled.

This dual concept of implementation and regulation is the central theme about which is organized the new Brookings Institution study of government in relation to economic activity in the United States.[2] The most difficult problem in treating this broad field comprehensively has always been the logical organization of the material. There is no dearth of competent studies, ranging from the popular and ephemeral to the most scholarly and abstruse, of special topics under this head. Whether it be public-utility regulation, bankruptcy law, shipping subsidies, food and drug control, or any one of a host of other special subjects, we can turn at once to an extensive literature. But to fit the multifarious aspects of government intervention into a logical pattern which permits the student to comprehend their anatomy and rationale without getting lost in the maze of detail is a notable achievement. It is the scheme of organization which makes this book unusual, and redeems it from being merely a collection of competent essays on special topics.

Even in so broad a study some limits have to be set. While the book is confined to experience in the United States, perspective is obtained by tracing the thread of many special topics from 1789, and by relating the historical development to current issues of public policy. As A. N. Whitehead has remarked, one can be provincial in time as well as in space. To know only the present is to be provincial in much the same way as is the villager who knows only his own hamlet. No better antidote than such a study could be found for the superficial view that government intervention is something recent, exceptional, unprecedented, regrettable, and transitory.

Even in the short history of our own government with its peculiarly individualistic tradition, the roots of many current policies extend from the beginnings of the nation. The pioneer way of life and a fierce spirit of liberty produced a government based on the English tradition of checks and balances, yet reacted vigorously against such abuses as lay within the experience and memory of the colonists. Such elements, operating upon the rich resources of a new continent, gave opportunity for a fresh start in human affairs, free from many ancient burdens of social tradition.

The first volume is devoted to types of government activity which apply quite generally to all industries and economic areas. It is to such activities that the concept of implementation versus regulation is particularly applied. The duality is never absolute; some admixture of aid and furtherance is found in the most restrictive regulations and conversely, the very effort to encourage an industry or occupation necessitates the establishment of administrative rules and limitations.

Six main types of government implementation are treated: The first is the establishment of organizational forms for private enterprise. To the promoter, corporation or partnership law may appear as a set of limitations, rather than as an opportunity. Fundamentally, however, such a body of law sets up instruments which further the operation of the spirit of enterprise. The law of business organization constitutes a set of limitations upon customers, creditors, employees, and competitors as well as upon the enterprise itself. Bankruptcy and reorganization procedure constitutes a second and closely related type of implementation.

Third, the provision of patent rights forms a specialized kind of encouragement to enterprise. Fourth, the entire monetary mechanism and the control of banking and credit is a facility which aids the conduct of business in general. That a field so broad and complex as this must here be passed over in a sentence illustrates the vast scope of a treatise of this sort.

Fifth, mechanisms to adjust labor disputes, provided under government auspices, are a way of furthering one aspect of the bargaining process. The authors distinguish these functions of mediation and arbitration from governmental activities dealing with labor in a regulatory way.

The sixth type of implementation, provision of knowledge, is of a distinct kind from the others. It gives rise to fewer controversies because less tinged with the character of regulation and control. Aid of this kind includes the creation of standards such as weights and measures, standards of quality in commodities, the issuance of technical data and research results, and the collection and publication of statistical information.

It will be noted that underlying most of this implementation are the fundamental institutions of property and contract. These are the basic elements out of which economic activity is organized in a free society. The authors omit general discussion of these fundamentals in order adequately to cover the special applications which form the theme of the book.

The remainder of the first volume outlines the great group of governmental functions which are applicable to the broad field of industry, rather than to special areas, and which are primarily regulative in character. In treating the antitrust laws and the Federal Trade Commission the authors make a useful distinction, not always clearly observed, between laws intended to *maintain* competition and laws intended to protect the *plane* of competition by forbidding unethical conduct. Acts in restraint of trade or tending toward monopoly fall in the former class. Such, for example, would be a price or output agreement among competitors, or intercorporate stock ownership contrary to the terms of the Clayton Act. In the latter class fall acts which deteriorate standards of fair competition, such as

[1] One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, The Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

[2] "Government and Economic Life," by Leverett S. Lyon, Myron W. Watkins, Victor Abramson, et al., Washington, D. C., The Brookings Institution, vol. 1, 1939, 519 pp.; vol. 2, 1940, 1301 pp.

passing off goods under false labels or the use of espionage and commercial bribery.

In contrast to the foregoing activities which concern business competition stands another great group of laws dealing with labor relations, and applicable over the whole range of industry. The discussion separates policy restricting concerted action by workers, such as the injunction and the antiunion contract of employment on the one hand from policy which has an opposite tendency, such as the various statutes restricting the use of these devices and the work of the National Labor Relations Board.

Separate chapters deal with policies that concern *methods* of concerted action (e.g., the strike and boycott), labor agreements and union responsibility in adhering to them, and finally terms and conditions of employment. The task of compressing the broad subject of protective labor legislation into this last chapter gives another measure of the encyclopedic scope of a study such as this.

The second volume is more conventional in its arrangement of topics, dealing with regulation applied to limited areas of economic life. There are excellent chapters dealing with such standard subjects as transportation, public utilities, bituminous coal, foreign commerce, agriculture, food, and drugs.

A particularly interesting anomaly in this part of the work is the presence of two chapters dealing with government control applied, not to particular areas, but broadly in scope on particular *occasions*. The occasions chosen are the period of the National Industrial Recovery Act and the World War. Every student who has attempted to organize a subject as large as the one in question will appreciate the need of overstepping a hard-and-fast logical scheme in order to gain practical working coverage of important issues. The authors have obviously done this in including these chapters. Viewed in the perspective of the past, these two periods of emergency were exceptional, leaving relatively little mark on the permanent development of government control. Viewed in the shadow of the present and the ominous future they suggest that a different scheme might be desirable. It seems not unlikely that emergencies of war and depression may be the normal order of things for some time to come. A more serviceable orientation of this study might have resulted if the special topics surveyed had been followed explicitly through the emergency periods. Wise policy in each area of government control may well prove to be that policy which best lends itself to emergency use, rather than a fair-weather policy which must be suspended with increasing frequency.

The last main section of the work deals with governmentally organized production. It is interesting to note that people rapidly come to take for granted the many forms of government production to which they have become accustomed, while viewing with grave misgivings any extension of this area. Government production in the United States includes tax-supported free services (such as education and the protection of person and property), mixed types of subsidized services, supported partly from public funds and partly from sales, and finally, out-and-out operation of government production for sales (such as the post office and municipal public-utility systems).

The approach to these problems throughout is analytical rather than descriptive. Three major questions are considered: "(1) Why is it felt appropriate that public agencies should produce some services and not others? (2) Why should some be rendered free and others at a charge? (3) Why is it appropriate for governments to be 'in business' in some fields and not in others?" The answers to these questions, as the authors point out, are not in the least obvious. "They not only take one to the central problems of political theory, but also call for a knowledge of the historical development of social environment and popular attitudes."

Separate chapters on public relief and on social security mark the book as recent, and as covering a broader field than control of industry in the narrow sense.

The perspective of a century and a half shows a swing from the early attempts at aid and encouragement of industry (such as tariff policy and "internal improvements") toward greater regulation and control, with rapid extension of special treatment for particular industries. Examples of the latter are found in petroleum and coal and in regulation of highway and air traffic. It seems now that we may be in for something of a reversal of this trend, in which encouragement of venture capital and other measures calculated to promote full production and employment will gain in emphasis in contrast to the measures of regulation which have been so prominent during the last decade.

Milwaukee's Contribution to Pulverized-Coal Development

(*Continued from page 726*)

against its development. Milwaukee was pictured as a modern Pompeii buried in ash from pulverized-coal installations. There was no doubt but that the fly ash was and still is a problem which defies an easy general solution. John Anderson decided on a special solution of this problem for the Lakeside plant. Each battery of four boilers was connected by an underground flue to a concrete stack located about 50 ft from the boiler plant. Part of this underground flue was made into a wet scrubber. A number of wooden grids with water spraying over them were placed in this flue in the path of the gases. A large part of the dust in the stack gases was caught on the wetted surfaces of the grids and was washed away by the water sprays which also kept the wood from burning. Although considerably better than 50 per cent of the dust was removed, the gases at the top of the stack still retained their cloudy color. The scrubber removed the larger particles of the dust which cause most of the nuisance, while the very fine particles which give the gases the cloudy color remained in the gases.

If a higher draft loss can be tolerated, the gas passages through the grids may be made smaller, thereby increasing greatly the efficiency of the scrubbing. More recently, in some of the English gas scrubbers of somewhat similar design, over 95 per cent of the dust has been removed from stack gases.

In reviewing the work done in Milwaukee, one is impressed by the great number of fundamentals which were investigated. Although no experiments on the removal of ash as a liquid were made there, little else of importance remained untouched. The effect of fineness on combustion, drying coal in the pulverizer, the excess air in the flue gas, the temperature and heat absorption in the furnace, methods of obtaining a thorough account of the distribution of the heat and ash from the coal, and the elimination of dust from the flue gases were all studied before pulverized coal became the commonly used fuel it now is for firing power-plant boilers.

Twenty years ago, at a time when pulverized fuel was not used by public utilities, Milwaukee showed faith in its use and was prepared to stand the expense and inconvenience of tests to determine whether this faith was justified. By diligent investigation and patience John Anderson and his associates were able to overcome the many difficulties which arose. The many boiler plants now using pulverized coal testify to the justification of this faith. No history of the development of pulverized fuel would be complete, unless it acknowledge the important role Milwaukee played in its development.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Day by Day

IN THE year that has elapsed since the invasion of Poland, the terror of mechanized warfare has spread in all directions from its origin in Central Europe. Its westward extension, begun with the invasion of western Europe in May and actively in progress at the present moment in the form of the aerial *Blitzkrieg* in England, has precipitated events in this country which will determine for us a new way of life under conditions that begin to fasten on us the burdens of national defense, for so many years an important factor in the life of Europe. Our defensive outposts, pushed eastward by the lease of air and naval bases from Newfoundland to South America, are a grim reminder of our disappearing isolation. The sale of fifty overage destroyers to Great Britain demonstrates the seriousness with which this appearance of isolation is viewed. A conscription, draft, or universal-service bill and appropriations for national defense already in excess of fifteen billions of dollars indicate how greatly we have changed from a nation whose "peacetime" military expenditures and social habits have been relatively free from the militaristic atmosphere that has pervaded Europe for generations to one which must condition its economy to the threat of invasion and assault. Engineering, from the fields of education to those of practice, will be forced to adapt itself to the changed conditions, and engineers of the future, individually and as a group, will be forced to add to their burden of advancing material progress the task of creating and maintaining in a state of high efficiency the defenses of democratic civilization. That the genius and determination of engineers to accomplish these new tasks will be adequate, none can doubt, provided national unity can be achieved.

It will be a source of satisfaction to many engineers in this country that an American engineer, long resident in London, Howard Bird, is honorary treasurer of the Americans-in-Britain Outpost, which is connected with the Committee to Defend America by Aiding the Allies, of which William Allen White is chairman. Letter No. 1, "News From the Outpost," bearing the date August 1, 1940, recently received, contains the following paragraph:

> The truth is emerging that the people of France were not only left unprovided with adequate arms, but far more serious still, they were to a disastrous extent deprived of the organized determination and will to fight. The whole story is not told in weight and numbers of tanks or load and speed capacity of planes. Underlying these things there must be determination, at all costs, to defend and maintain that form of government which a people have evolved out of their own experiences and necessities. That determination is the supreme motive force which we find in Britain today. It is also the creed of the American people.
>
> One thing is sure. The eyes of the world are on America and Britain.

The purposes of the Outpost are to act as an observation post for the William Allen White committee and as the personnel bureau and information center of various American relief organizations in Britain.

L. P. Breckenridge

On August 22, 1940, in his eighty-third year, Lester Paige Breckenridge, professor emeritus of mechanical engineering, Yale University, and past vice-president A.S.M.E., died suddenly at his home at Mt. Philo, North Ferrisburg, Vermont. His death was preceded by no physical or mental disorders; his keen, enthusiastic zest for life and people, his customary orderliness of mind and habits, his ageless exuberance of spirits suffered no slackening; he was spared that tragic deterioration of mind and body that sometimes makes old age a burden rather than a benediction.

The hundreds of "Breck's boys," whose ages may range from 45 to 75—men who came under his influence as a teacher at Lehigh, at Michigan State, at Illinois, and at Yale—will rejoice to learn that the man they knew had been thus kindly dealt with by time. Those who saw him in recent years noticed no dimming of the brilliant personality that caught their fancy years ago and has remained with most of them ever since, an inspiration scarcely less vivid than it was when it was first encountered in their impressionable youth. His passing will no more destroy that influence and that inspiration than did severance from him at graduation of those unfortunate ones who met him infrequently or not at all after their college days and who still said, "Remember me to Breck when you see him."

What Breck achieved as an engineer and educator was the consequence of a personality as brilliant in retirement as it had been in active life. Few men retire gracefully; but Breck's qualities of mind and character were such that retirement was merely the transference from a stage he had long trod to another that was broader, in a way, for it ranged from Italy to California, and less public, for he shunned classrooms and lecture platforms, and one that held the mirror equally as truthfully to humanity and the rich realities of living. But no one seeking the reasons for so satisfying a success in what is called retirement can overlook the part played in it by Mrs. Breckenridge who was his constant companion, indulged his affection for people, and provided many of the sources of his enthusiastic avocations.

The wholesome simplicity of a man who derives his chief pleasures from his contacts with his fellow men is a more abiding blessing than his technical contributions to engineering. It was through this quality that Breck became known in Italy as "the Mayor of Sorrento." If he loved the Italians it was because even the humblest of them were human beings. If the Italian peasants loved him it was because he was a man who understood them, who ate his lunch in their dooryards, who admired and photographed their children, who talked in simple terms to them about their joys and sorrows.

"I speak verbless Italian," it amused him to say. "Mrs. Breckenridge conjugates Italian and I decline it. I can do three things in Italian: I can count money, order food, and be polite." What more universal language is there to open the hearts of men to responsive honesty and good will?

On one of their walks in the Italian countryside Breck one day horrified his wife by announcing his intention of invading a one-room schoolhouse by the side of the road. "Why not," he replied, "I'm a school teacher." And in he went. Soon the young school teacher had all the children lined up outside to

have their pictures taken and Breck was calling them all by name. Prints of the photograph were sent back for every pupil and for many months they served as rewards for good behavior. Today the girls of this group are probably bearing children and the boys killing and being killed under orders, for the simple kindliness that disciplines schoolrooms and families seldom extends to high places.

A man who understood as clearly as Breck did the working of men's minds could entertain also a sympathetic communion with nature's other creatures. There were the many generations of chipmunks that burrowed behind the Vermont cottage, for example. Mr. Wall Street, so named because he worked in the "bank," and his numerous progeny, early learned to trust the kind benevolence of Breck and to discover peanuts (in the shell, of course, because even a chipmunk must work for his living) in all sorts of outlandish places, fruit jars, cartons, Breck's pockets, and elsewhere. They came at his call, and to them Breck taught the kindly disciplines and homely virtues that have so successfully guided "his boys."

L. P. BRECKENRIDGE ON HIS 65TH BIRTHDAY, SEATED AT HIS DESK IN MASON LABORATORY, YALE UNIVERSITY, MAY 17, 1923, ONE MONTH BEFORE HE RETIRED FROM ACTIVE TEACHING

Along the roadsides of Italy blossom the heavenly blue morning glories, reflecting the clear brilliance of the sky as faithfully as does the Bay of Naples spread out below the terrace of Breck's Sorrento hotel. They hold something of the open-faced abundant beauty the world affords to those who have eyes to see it and a sense of values to comprehend it. Breck saw and comprehended. The seeds he carried everywhere and distributed to fellow travelers from all over the world. For years, and until a New York seed merchant stocked them, Breck's seeds germinated, grew, and blossomed all over the world through the efforts of a one-man organization—Breck's International Heavenly Blue Morning Glory Club. Into a world where combinations of initial letters strike terror and confusion in the hearts of men, BIHBMGC, as Breck whimsically called his organization, has brought nothing but joy and beauty. "Somewhere in the world," he used to say, "Breck's heavenly blue morning glories are always in bloom." On the trellis by the little white house that looks out over the waters of Lake Champlain, in window boxes in London, in gardens on the underside of the world—South Africa, New Zealand, Australia—they still blossom to cover the scars of war on alien landscapes and the scars of sorrow in men's hearts.

America's Resources

In striking contrast to the familiar emphasis placed on the unpreparedness of America in all areas of national defense that have been filling the press and the ether with recriminations and warnings, a little pamphlet, "The Great Reliance for National Defense," published by Farrel-Birmingham Company, Inc., Ansonia, Conn., is a reminder of the exceptional resources we possess in machinery and productive capacity. Germany and Italy, it is said, have a combined total labor supply of fifty-six million persons as against some fifty-five million, employed and unemployed, in this country. Including all the Axis powers, the conquered nations, and others that might be our potential enemies, it will be found that we are greatly outnumbered in labor supply. But with respect to the capacity of the machinery-producing industries to expand our total of installed horsepower, our situation is perhaps more favorable than the public realizes, the booklet contends, sufficiently so to provide assurance that we can equal and surpass the working power which may possibly one day be opposed to us. Given free rein, wise direction, and backed by a national will to produce and prepare, it is concluded that machinery becomes the great American reliance for defense.

Statistical evidence, conveniently and attractively presented, of "what industry can do for America," is to be found in the August issue of *Factory*. It particularizes some of the industrial and economic conditions existing in this country upon which the broad generalizations of the booklet already referred to are based. Editorially, the challenge to industry is stated as the task of creating a better livelihood for the American people, producing at the same time materials for a national defense that will insure national survival.

The evidence, assembled from various authoritative sources, undertakes to show (1) what industry can do for America, (2) why America lives as well as it does today, (3) why America could live much better, (4) what is holding America back, (5) how America can go ahead, (6) how one city's industry is helping America, and (7) how one industrial plant is helping America. The method of presenting the evidence combines a forceful text, significant illustrations, and statistics graphically presented by picture charts easy to read and comprehend.

This impressive display of America's wealth in material and human values, developed under a democratic government and a system of free enterprise and equality of opportunity, dramatizes at once the great stake involved in national defense and the capacity to defend America that exists in these resources. In addition to the national and industrial challenge hurled at us by swiftly moving world changes, the goal is revealed by *Factory* of some of the yet unattained benefits that the future holds when peacetime pursuits can once more be undertaken with renewed courage, determination, and unity of purpose. The facts presented provide the incentive to defend that which we now have in order that we may lead the way out of the present chaos into a happier future. They serve to strengthen faith in democracy and free enterprise.

Rice Scholarship

Friends of the late Calvin W. Rice, for more than a quarter of a century secretary of The American Society of Mechanical Engineers, will recall with satisfaction Mr. Rice's keen interest in international amity and his particular efforts to increase the friendship and understanding existing between the United States and the countries of South America. In recognition of Mr. Rice's international reputation and services the Society established the Calvin W. Rice lectureship, filled in 1939 by Rodolfo E. Ballester, of Argentina. In 1938 the Woman's Auxiliary of The American Society of Mechanical Engineers established the Calvin W. Rice Memorial Scholarship for South American students in mechanical engineering. The first recipient of this scholarship, Eduardo Ramon B. Abril, of Argentina, was chosen by the Auxiliary at a recent meeting on nomination by the scholarship committee, Mrs. Ansel Brooks, chairman. Mr. Abril, who also received a tuition scholarship from the Massachusetts Institute of Technology, and a travel scholarship from The Pan-American Airways, is expected to arrive in this country early in September and will take up his studies at M.I.T. this fall.

Mr. Abril was educated in Argentina, studied mechanical and civil engineering, and was granted the degree of mechanical engineer in 1939. In 1935 he entered the military-airplane factory as a draftsman where he worked for three years. During this time he invented an airplane compass which was constructed in the factory and won for him the commendation of the Director General of Aeronautics of the Army. Upon leaving the airplane factory he entered the general board of hydraulics for the province and participated in several hydraulic projects. During the last year he has undertaken a study of the rational section of canals and has developed formulas to facilitate calculations. He is interested in sports, and in 1933 won the title of national champion in basketball.

Rockwell

It is appropriate to record the passing, on August 11, of Stanley P. Rockwell, metallurgist and originator of the Rockwell hardness tester. Mr. Rockwell was a graduate of the Sheffield Scientific School, Yale University, in the class of 1907 and recipient of the Sauveur Medal of the American Society for Metals. From 1912 to 1917 he was employed by the New Departure Company, during which time he developed the Rockwell hardness tester. During the World War he was a captain in the Ordnance Department in charge of testing. He was formerly a member of the A.S.M.E.

New Die-Milling Method

1940 SEMI-ANNUAL MEETING, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

A NEW method of tool and die milling, which makes possible the complete milling of dies at one setup, is described in a paper presented by Francis J. Trecker, junior A.S.M.E., at the 1940 Semi-Annual Meeting of The American Society of Mechanical Engineers, Milwaukee, Wis., June 17–20. With this method, there is no necessity of lengthy layout operations, numerous transfers from machine to machine, and excessive hand operations. The principle behind the method is the precise mechanical control of the cutting element so that it is possible to produce straight, angular, and radial movements in both horizontal and vertical planes.

In a machine tool employing this principle, the work spindle

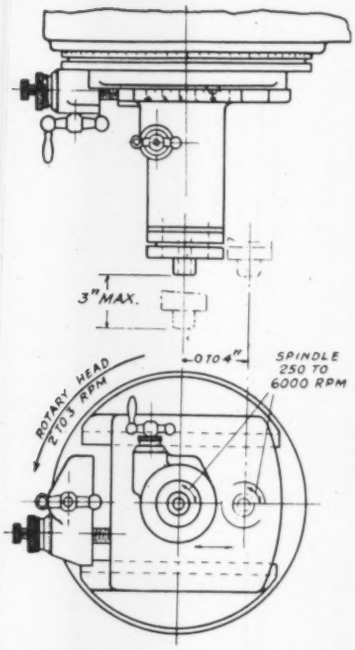


FIG. 1 ROTARY-HEAD DIAGRAM, SHOWING MOTION OF HEAD, OFF-CENTER POSITION OF SPINDLE, VERTICAL ADJUSTMENT, AND LIMITS OF MOVEMENTS

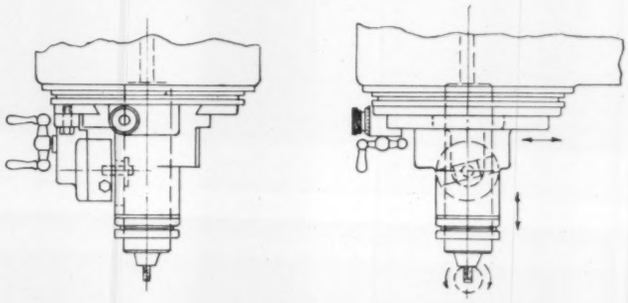


FIG. 2 MANNER IN WHICH CHERRYING ATTACHMENT IS MOUNTED AND ITS METHOD OF OPERATION

is mounted and controlled so as to move the cutter in straight, angular, and radial motion in both horizontal and vertical planes. The spindle is placed on a cross slide which, in turn, is contained in a rotating unit or rotary head, making it possible for the spindle to be set off-center by means of a precision-ground screw and micrometer dial. Inasmuch as the rotary head can be set by hand or power at any particular degree through 360 deg, which in turn sets the angle of the cross-slide movement of the spindle, the operator can move the spindle to any angle in the horizontal plane, as shown in Fig. 1.

The spindle is quill-mounted, permitting vertical movement of the cutter by hand or power. A mechanical control, which combines the off-center motion of the spindle with the vertical motion of the quill, moves the cutter in either the radial or angular path in the vertical plane. This mechanical control is illustrated in Fig. 2. In the terminology of diemakers, it performs the function of making "cherrying" type of cuts. Before the advent of a mechanical method of machining cherrying cuts, it was necessary to have a special shape and diameter of cutter for every different cut. The present method is to vary the diameter of the cut by mechanical means.

The cherrying attachment is anchored to the fixed portion of the rotary head, while the spindle is mounted on a cross slide which permits motion in the horizontal plane relative to the

cherrying attachment. Since the spindle is quill-mounted, it permits vertical motion. The pin projecting from the quill is the means by which the motion of the cherrying attachment is transmitted to the spindle, causing it to move horizontally and vertically.

One of the advantages of this new method is the completion of dies at one setup. The die is placed on the table and all layout work, milling, drilling, boring, and slotting operations are completed without resetting the die, resulting in saving of time and increase in the accuracy of the die. It is also possible to lay out multiple-cavity dies by this method. The advantage of this is that all cavities are exact duplicates of each other, especially important when interchangeability of parts is necessary.

Machine-Tool Handling

1940 WORCESTER MEETING, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

THE transfer of machine tools from storage to a demonstration room of the plant without the aid of a crane or lift platform is now being accomplished at the plant of the Leland-Gifford Co. by means of a forked lift truck specially designed for the purpose. This truck and its operation were described by

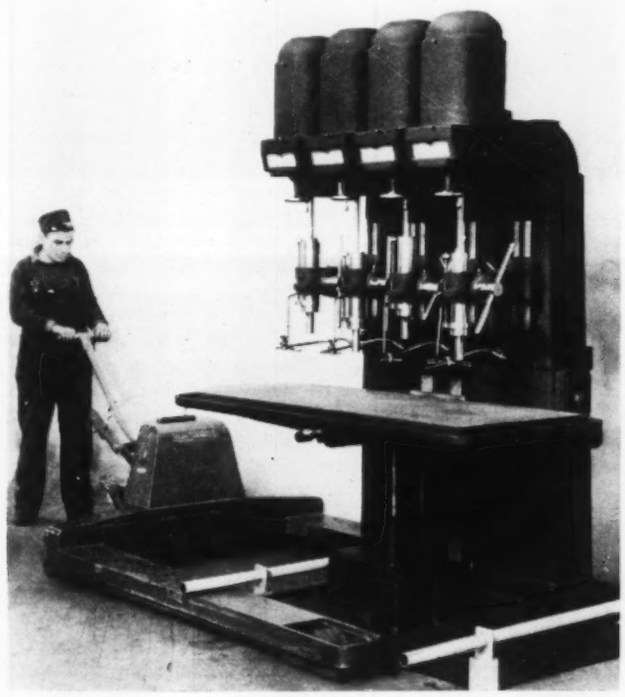


FIG. 3 SPECIAL LIFT TRUCK AND CLAMPING DEVICES DESIGNED FOR CARRYING MEDIUM-SIZE MACHINE TOOL

A. L. Wilkinson at a session sponsored by the A.S.M.E. Materials Handling Division during the 1940 Spring Meeting of the Society in Worcester, Mass., May 1–3.

After a conference with a manufacturer of materials-handling equipment, the U-shaped lift truck shown in Fig. 3 was developed together with a set of special clamps and a new type of machine base. Among the features of the truck are the use of customary methods of raising and lowering its upper surface as a unit, a three-point method of support, a capacity of 6000 lb, small vertical lift to enable high machine tools to enter a room that has a door clearance of four inches over the highest machine, a facility to maneuver, making it possible to arrange machines on the floor, and ability to pick up a machine from the storage floor and deposit it again solidly on the demonstration-room floor in the desired location, leaving no skids, bars, or platforms under the machine.

A hanger, Fig. 4, is placed on each corner of the machine base, as shown in the illustration. Since the corner of the machine base is slightly recessed, the lower part of the clamp slips under. To keep the clamp from slipping off, a steel pin is slipped through its upper and lower parts and a hole in the machine base. Finally, pipes or steel rods are slipped through the two clamps at each end of the machine. This enables the forks of the lift truck to raise all four corners of the machine base at one time.

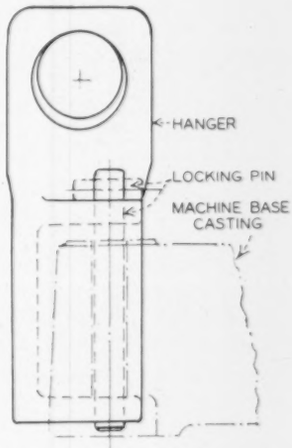


FIG. 4 HANGER IN PLACE WITH LOCKING PIN IN POSITION

Utilization of Uranium Energy

RADIO STATION WBZ, BOSTON, MASS.

THE energy of the split uranium atom, U 235, was used for the first time on July 27, 1940, to turn on the new 50,000-watt, air-cooled transmitter of radio station WBZ in Boston, Mass. During a special ceremony the explosive force of a single U 235 atom was released to start a chain of electrical reactions ending in the switching of the program from Millis to the new transmitter in Hull. The splitting of the uranium atom was clearly audible to the radio audience as a sharp click.

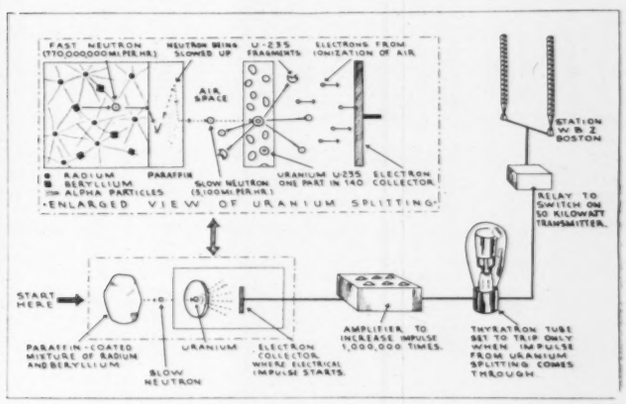

FAST NEUTRON (170,000,000 MI. PER HR.)
NEUTRON BEING SLOWED UP
U-235 FRAGMENTS
ELECTRONS FROM IONIZATION OF AIR
AIR SPACE
RADIUM
BERYLLIUM
ALPHA PARTICLES
PARAFFIN
SLOW NEUTRON (5,100 MI. PER HR.)
URANIUM
U-235 ONE PART IN 140
ELECTRON COLLECTOR
ENLARGED VIEW OF URANIUM SPLITTING
STATION W B Z BOSTON
RELAY TO SWITCH ON 50 KILOWATT TRANSMITTER.
START HERE
PARAFFIN-COATED MIXTURE OF RADIUM AND BERYLLIUM
URANIUM
SLOW NEUTRON
ELECTRON COLLECTOR WHERE ELECTRICAL IMPULSE STARTS.
AMPLIFIER TO INCREASE IMPULSE 1,000,000 TIMES.
THYRATRON TUBE SET TO TRIP ONLY WHEN IMPULSE FROM URANIUM SPLITTING COMES THROUGH

FIG. 5 DIAGRAM SHOWING RELEASE OF ATOMIC ENERGY TO START TRANSMITTER OF WBZ

As shown in Fig. 5, a piece of uranium about the size of a dime is used in the apparatus designed for the occasion. One atom in every 140 of this piece is in the form called U 235, the form which has recently been found to give up enormous amounts of energy when split by slow neutrons. The uranium splitting takes place inside a metal container known as an ionization chamber. Slow neutrons are obtained from a mix-

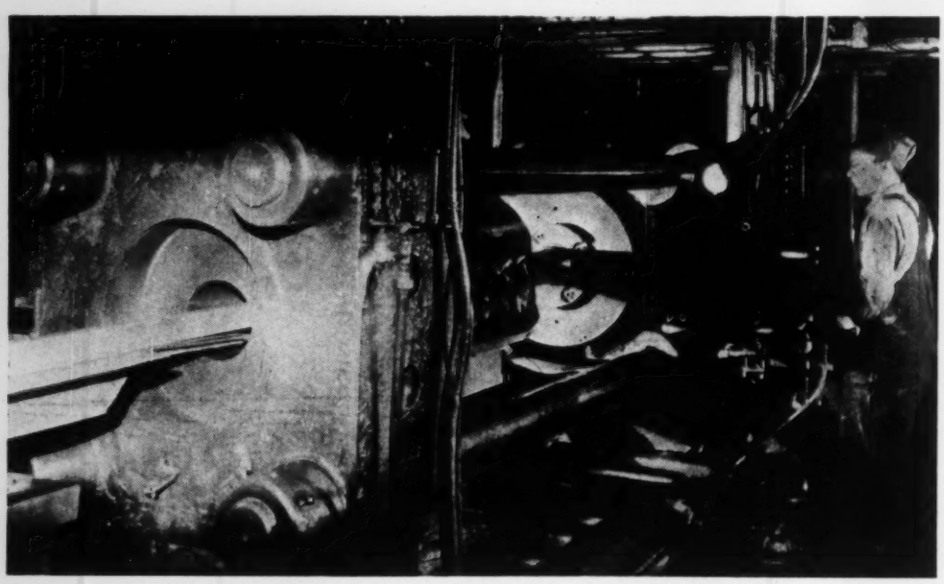
ture of radium and beryllium, encased in a coating of paraffin wax.

Alpha particles, which are atomic fragments emitted constantly by radium in its natural process of disintegration, bombard neighboring atoms of beryllium, causing a minor atomic splitting. The beryllium becomes carbon and a fast neutron shoots out at a speed of about 770,000,000 mph. In passing through the coating of paraffin, the neutrons slow down, by being bumped back and forth by atoms of hydrogen, to the atomic walking pace of about 3100 mph. Then they cross an air space of a fraction of an inch and strike the uranium piece with the energy of about one fortieth of an electron volt.

Not every neutron hits the uranium directly, but on the average of once in every ten seconds a neutron reaches the nucleus of the U 235 atom. Then an atomic cataclysm takes place. The U 235 atom explodes, being divided about equally into two other atoms of about equal weight. As a by-product, three more neutrons are expelled. All these atomic fragments repel each other with such speeds that 200,000,000 electron volts of energy are released.

As the fragments fly through the air in the chamber, they graze atoms of oxygen and nitrogen and knock off many electrons. This phenomenon is known as ionization. The stray electrons are attracted toward the electron collector and in doing so set up a small current in an electric circuit. By the time this tiny current has been amplified about a million times by a series of vacuum tubes, it is strong enough to start a Thyratron tube which acts as a trip valve. The Thyratron in turn closes a relay switch which was used to turn on the transmitter of WBZ.

The 200,000,000 electron volts of energy released in the splitting is quite large on the atomic scale. But an atom is so small that it would take millions of such atomic fissions to be felt in the world of power generation. For example, it has been estimated that if the U 235 fissions took place at the rate of 100 times per second—that is, one thousand times as often as in the experiment just described—they would give off the same amount of energy that radio waves impart to the antenna of a radio receiving set if it is located about 50 miles from the broadcasting station.



MAGNESIUM ALLOY, ONE THIRD LIGHTER THAN ALUMINUM, BEING EXTRUDED

(The growing demand for magnesium alloy, which has great strength, toughness, and durability, in the aviation, bus, railroad, and general transportation industries, as well as in the manufacture of lightweight portable tools, household and office appliances, made it necessary to discover new sources of magnesium. After years of research, The Dow Chemical Company has started to build a plant at Freeport, Texas, to extract the metal from the sea where an unlimited source of magnesium exists. It has been estimated that one cubic mile of sea water contains 5,700,000 tons of magnesium, enough to keep the new plant operating at full capacity for 800 years.)

Progress in Petroleum

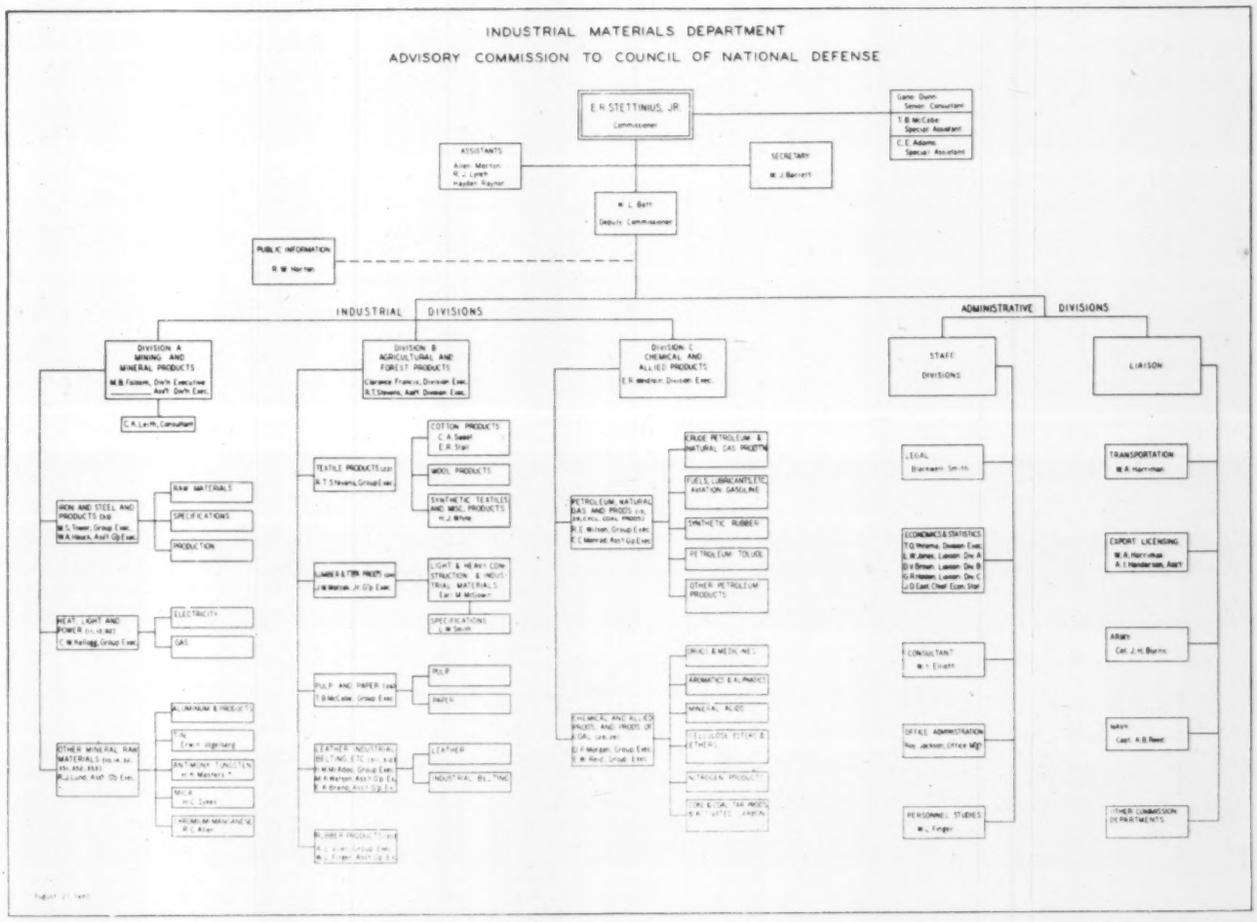
SCIENCE

CRUDE oils are a source of substances that are the foundation stones of a number of industries with many more to come, declares Dr. Gustav Egloff in a paper appearing in *Science* for June 7, 1940. Their effect, he continues, ramifies throughout our social and economic life and they will be a controlling factor in ultimate victory in a world aflame.

An amazing amount of research is going on in every branch of the industry at an expenditure of more than $100,000,000 a year in order to discover and transport crude oil to refining centers for conversion into products useful to mankind. Many of the 360,000 oil wells in operation in the United States were drilled in recent years, but substantial production still comes from wells brought in more than fifty years ago in the original oil state, Pennsylvania. The deepest well drilled so far is about three miles in depth. (See MECHANICAL ENGINEERING, August, 1938, page 630.) It is certain that wells will be drilled and oil found at depths of five miles or more.

Crude-oil reserves of today in the known oil fields are about 20,000,000,000 barrels. During the last year alone, approximately 2,000,000,000 barrels of crude were added to the country's oil reserves above that actually used. Through the years crude-oil reserves have been increasing by the discovery of new oil fields, by deeper drilling in old fields, and by hydrochloric-acid treatment, called acidizing, of old and new oil sands. One of the greatest forces for conservation and well being of our social and economic life is the cracking process developed by chemists and engineers of the oil industry. This process has more than doubled the yield of motor fuel from a barrel of oil with antiknock quality which gives in excess of 40 per cent more miles per gallon than Nature's gasoline. Since 1913 when the first commercial cracking plant was used to the present time, a saving of more than 13,000,000,000 barrels of crude oil has been brought about.

There is an ever-recurrent cry that crude oil is an irreplaceable asset. However, there is evidence to contradict this view. The author believes that petroleum is being formed in the earth at a greater rate than it is being consumed. So far as it is known, Nature may still be going ahead with the same biochemical changes, the same heat, pressure, and time processes by which crude oil was made in the beginning, at least in part. Investigations have brought to light facts regarding earth processes



ORGANIZATION CHART, INDUSTRIAL MATERIALS DEPARTMENT, ADVISORY COMMISSION TO COUNCIL OF NATIONAL DEFENSE

which from their very nature lead the author to the belief that oil is continually being formed, although they have not been sufficiently established to confirm it positively. As a matter of interest, since the founding of the petroleum industry, the entire world's production of crude oil would not fill a hole a cubic mile in the earth. This is an insignificant volume compared to what Nature must have produced and is producing during years of her workmanship.

The increasing number of high-compression engines has made straight-run gasoline no longer suitable as fuel. Cracking or reforming of the gasoline is necessary to produce hydrocarbons of structures which possess greater antiknock properties. In order to convert the knocking gasoline into nonknocking types, it is desirable to subject the gasoline to temperatures of the order of 1025 F and pressures of 750 psi. This is accomplished by pumping straight-run gasoline through a long heating coil distributed in a furnace, until the temperature and pressure are raised to convert the hydrocarbons into high antiknock gasoline. Under these drastic temperatures and pressures, there is a molecular rearrangement and change in the structures of the hydrocarbons from the straight-chain paraffinic type to branched paraffins, olefins, aromatics, and naphthenes. These hydrocarbons burn without detonation in the high-compression engines of today.

It was recognized that thermally cracked gasoline was approaching a limit from the antiknock-quality standpoint. The octane number averaged about 70 as produced from gasoline, naphthas, or heavy oils. Hence, catalytic-cracking processes have been developed to increase the octane rating and yields above that of thermal. Catalytic-cracked gasoline of 80 octane has been produced from gas oil with yields of 85 per cent on a recycle basis. Catalytic cracking will be an adjunct to thermal cracking for some time to come.

The gases produced from the cracking process amount to over 350,000,000,000 cu ft a year. These hydrocarbon gases were formerly burned under stills and boilers. But these gases contained olefins such as ethene, propene, butenes, and the corresponding paraffins—ethane, propane, and butanes. So several processes were developed to convert cracked gases into high-octane motor fuel via high temperatures and pressures while catalytic process using solid phosphoric acid operates at low temperatures and pressures.

The butane-butene fractions from either the cracking or dehydrogenation process may be catalytically polymerized to yield isooctenes, and upon hydrogenation, isooctanes of 95 to 100 octane rating. The conditions for the manufacture of isooctane require temperatures of 250 to 350 F and approximately 750 psi with solid phosphoric acid as the catalyst. Debutanization and rerunning of the polymers is carried out and finally catalytic hydrogenation with nickel yields an aviation gasoline of 97 octane rating. For years it was believed impossible to react a paraffin with an olefin hydrocarbon, due to the so-called unreactiveness of the paraffins. However, a new page in organic chemistry has been written based upon an alkylation of isobutane with ethene, propene, and butenes by a number of methods such as aluminum chloride, boron fluoride, sulphuric acid, and at high temperatures and pressures. The latter two processes have gone into commercial use in the last year and

produce products having about 95 octane rating and high tetraethyl-lead susceptibility.

Military airplanes in 1928 used gasoline of about 60 octane rating while three years later the standard army aviation gasoline was 87 octane. Airplane engines were developed to utilize this fuel which gave a 33 per cent increase in power per unit weight compared to 60 octane gasoline. Engines designed for using 100 octane gasoline produced 30 per cent greater power output compared to 87 octane, while take-off distances were reduced 20 per cent and climbing speed increased 40 per cent. For transport planes, the advantage of 100 over 87 octane gasoline in a 1400-mile flight would be the dispensing of "1200 lb of gasoline and carrying instead seven more passengers, or their equivalent weight in mail or freight."

A most significant factor in the development of 100 octane gasoline is that the over-all efficiency of the airplane gasoline is about the same as that of the best Diesel airplane-engine performance and in addition surpasses the Diesel in greater take-off and emergency power and flexibility in maneuvering the airplane. Although 100 octane gasolines and higher are now used only in airplanes, it will not be many years before the oil industry's researches will produce them at a price level for use in passenger, truck, and bus vehicles, which will be sharply competitive with the best high-speed Diesel-engine performance.

The volumes of 100 octane gasoline potentially available yearly in the United States are greater than the volume of all gasolines now being produced. One prolific source which has been tapped recently is natural and refinery gases. From these gases alone 8,345,000,000 gal of 81 octane, or 3,275,000,000 gal of 92 octane, unleaded, gasolines are available. About 6,000,000,000 gal of 100 octane aviation gasoline are available yearly when the 92 octane is blended with isopentane and neohexan and light ends from some crudes plus tetraethyl lead. This volume of aviation gasoline does not take into consideration the vast volumes of aviation stock which are potentially available from catalytic reforming and cracking.

Benzene, toluene, and xylenes are not only important for motor-fuel use, but also as the basic materials for high explosives such as picric acid, TNT, and trinitroxylene. The oil industry can produce any conceivable amount of these hydrocarbons from catalytic cyclization or aromatization of gasoline, the cracking process, and dehydrogenation of ethane. In 1940 about 26,000,000,000 gal of gasoline will be produced in the United States. Based on this production, and using but 20 per cent of the gasoline, the United States could manufacture (naturally requiring some time to go into full production) about 33,000,000,000 lb of picric acid, about 27,000,000,000 lb of TNT, and 25,000,000,000 lb of trinitroxylene. The 85,000,000,000 lb of high explosives which are potentially available from gasoline are all present within the boundaries of the U. S. A. and will be for many years to come.

In the World War now going on, difficulty will be experienced in obtaining natural rubber for the country's needs. Some suggestion has been made to plant rubber trees in a South American country such as Brazil. It would require about ten years to obtain rubber in this way. Benzene and ethylene through alkylation and dehydrogenation yield styrene, a starting hydrocarbon for synthetic-rubber manufacture. Butadiene is another hydrocarbon which can be readily produced and converted into synthetic rubber or may be copolymerized with styrene. This latter type of synthetic rubber has about 30 per cent greater wear quality and strength in tires than natural rubber. The United States has potentially available enormous quantities of these hydrocarbons and other substances which can be converted into synthetic rubbers. In 1939 about 1,100,000,000 lb of natural rubber were used in this country. Over 200,000,000,000 lb of synthetic rubber could be produced from ethylene from the cracking process, benzene from cyclization, and butadiene from the dehydrogenation of butane. A unit to produce 10,000 lb a day of synthetic rubber from butadiene derived from petroleum is now being installed.

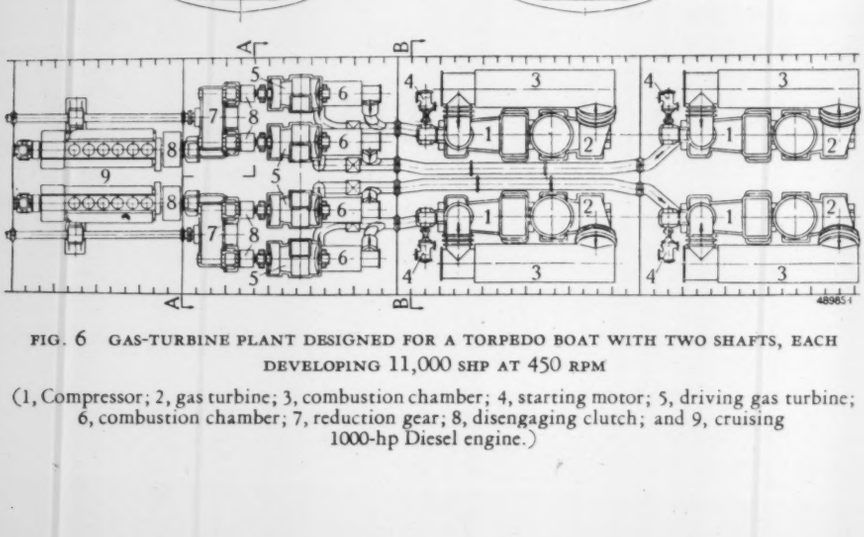


FIG. 6 GAS-TURBINE PLANT DESIGNED FOR A TORPEDO BOAT WITH TWO SHAFTS, EACH DEVELOPING 11,000 SHP AT 450 RPM

(1, Compressor; 2, gas turbine; 3, combustion chamber; 4, starting motor; 5, driving gas turbine; 6, combustion chamber; 7, reduction gear; 8, disengaging clutch; and 9, cruising 1000-hp Diesel engine.)

Marine Gas Turbines

THE BROWN BOVERI REVIEW (SWITZERLAND)

IT WAS only last year that the first paper on the combustion gas turbine was presented before The American Society of Mechanical Engineers and published by MECHANICAL ENGINEERING (see issue of Sept., 1939, p. 645). A little later an American company acquired from the Swiss builders the rights to manufacture turbines in this country. In Switzerland, a complete gas-turbine plant was recently constructed and tested (MECHANICAL ENGINEERING, March, 1940, p. 239). Encouraged by the results achieved thus far, Swiss engineers, according to an article in *The Brown Boveri Review*, Jan.-Mar., 1940, have been investigating the possibilities of the gas turbine for driving ships. Although conditions for marine plants are different from those for land plants, the gas turbine holds interesting possibilities for naval and merchant-marine purposes.

In a warship, the main characteristics demanded are that the propelling plant be light in weight, take up little space, and, if possible, be simple to operate and maintain. Even in its present stage of development, the gas turbine has all these characteristics. In a plant of this type, as shown in Fig. 6, there would be no boiler, and no condensers with their cooling water pumps, condensate pumps, and feed-water pumps. However, in order to achieve a low fuel consumption at cruis-

ing speed, it would be necessary to put in Diesel engines for cruising and to start the gas turbines.

Marine gas-turbine plants differ from land installations mainly in having to be reversible. They are, therefore, built with two gas turbines each. One gas turbine drives the compressor. Since the compressor set delivers no mechanical power, its gas turbine only uses 75 per cent of the compressed air from the compressor. The remaining 25 per cent is led to the driving turbine. In going astern or in maneuvering, the compressed air would be taken from the compressor without its being heated, thereby making it unnecessary to use turbine blading designed for high temperatures.

At full speed ahead, the air is brought up to full temperature in a combustion chamber, which forms part of the driving turbine, before being led to the ahead blading stages of the turbine. If propellers with adjustable blades are ever designed, the astern blading could be eliminated and it would not be necessary to separate the compressor set from the driving turbine, thereby simplifying the whole plant.

For merchant ships, which travel two thirds of their useful lives at about 70 per cent of their full engine power, only gas-turbine plants with an air preheater should be considered since the use of a preheater makes possible a thermal efficiency of 23 per cent. This type of installation is cheaper to operate than a Diesel engine in those countries where fuel oil is cheaper than Diesel oil.

New Power Installations

POWER

CONTAINED in the September, 1940, issue of *Power* are 15 pages of tables summarizing the facts about the ordered or completed additions to the country's power capacity, both steam and hydroelectric, since January, 1939. More than 700,000 kw of central-station power is scheduled for operation during the latter half of 1940, almost 2,000,000 more for 1941. The tabulation of industrial power plants shows over 400,000 kw on order or under construction. There is being added to municipal power plants more than 200,000 kw of capacity. About 1,000,000 kw of hydroelectric installations under construction or on order, mostly on government projects, complete the picture.

Multiengine Power Unit

COLLEGE OF ENGINEERING, UNIVERSITY OF KENTUCKY

GIVEN the problem to design and build a power unit that would generate 175 kw for use in the school's arc furnaces, the students in the College of Engineering, University of Kentucky, have developed a novel design consisting of six standard Plymouth automobile engines and a unique drive system. The multiengine power unit, described in detail by Edgar S. Foreman, student member from the University of Kentucky A.S.M.E. Branch, at the Society's 1940 Southern Group Meeting, Birmingham, Ala., April 1–2, has been adjusted to use natural gas. Mr. Foreman estimates an operating cost of 0.9 cent per kwhr, which includes replacement of the automobile engines after every 3000 hours of accumulated service.

As shown in Fig. 7, the clutch housing of each engine is fastened by studs to a casing or drum which contains the drive system, while the front end of the engine is supported by a framework of structural steel. The drum consists of a channel rolled into the form of a circle, welded, and closed both front

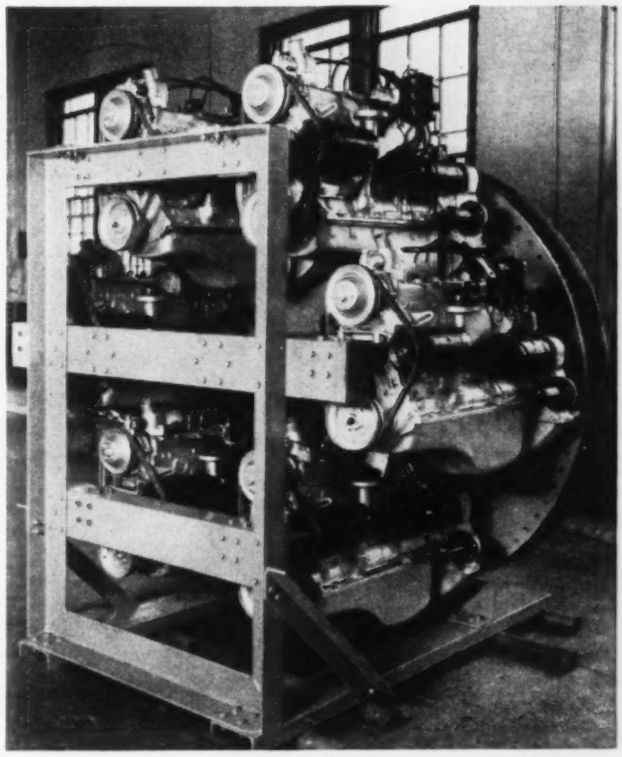


FIG. 7 REAR VIEW OF MULTIENGINE POWER UNIT

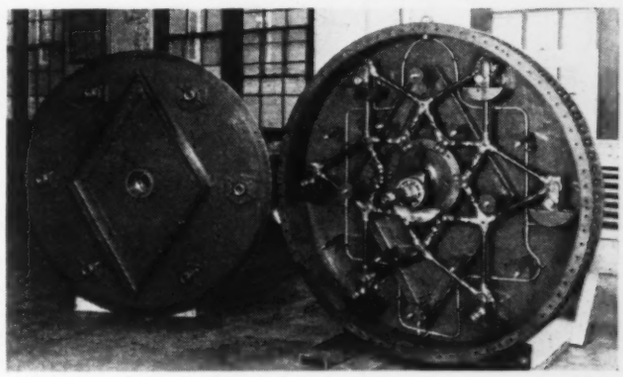


FIG. 8 MULTIENGINE DRIVE MECHANISM AND CASING

and rear by flat circular plates which support the main bearings of the drive system.

This drive, shown in Fig. 8, applies the driving force of the six engines to a central crankshaft. As shown, the six outer crankshafts are held in bearing supports in the casing at points corresponding to the center line of the engine crankshafts. Through the center of the drum and at the center of the circle on which the engines are mounted is a large split or built-up crankshaft of the aircraft-engine type. It has the same stroke as the other six individual crankshafts and is connected to them by means of a "spider." This is a rigid structure constructed of seamless steel tubing, the ends of which are inserted in manganese bronze sockets and silver-soldered in place. The center of this structure is connected to a cast-iron disk, which contains the bearing for the crankpin of the main shaft. Balancing is achieved by counterweights on each of the seven crankshafts.

The lubricating system of this drive mechanism is kept

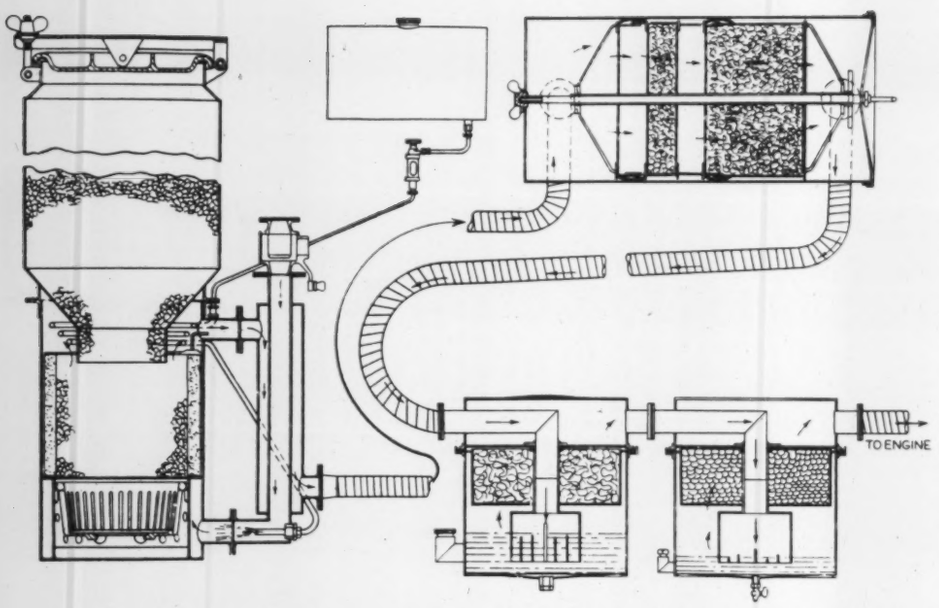


FIG. 9 GENERAL ARRANGEMENT OF BRUSH-KOELA GAS PRODUCER, SCRUBBER, AND FILTERS FOR USE IN MOTOR VEHICLES

separate from that of the individual engines. An oil pump which is driven from one end of the central shaft delivers oil under pressure to a system of tubing on the inside of the drum and to the main bearings of the crankshafts. The oil thrown off by the different cranks drains to the bottom of the casing from where it is led to a small tank surrounding the oil pump. The central crankshaft also drives the governor. Angle irons fastened to each plate in the form of a diamond stiffen the plates, and stay bolts with spacers keep the plates parallel.

Each of the six smaller crankshafts has a splined end which engages the driven disk of the engine clutch. The clutches are the same as used in regular automotive installations and are operated individually. This feature enables any or all of the engines to be started, after which any other engine may be started by simply engaging its clutch. The number of engines in use is dependent entirely upon the load.

Producer Gas for Autos

THE AUTOMOBILE ENGINEER (GREAT BRITAIN)

WITH the outbreak of the present war, gasoline and fuel oil in Great Britain became scarce for commercial purposes and could only be obtained at fabulous prices. This caused operators of automobiles, trucks, and buses to turn to other sources for their fuel. For example cheap producer gas can be used with little or no change in the carburetion, and some motor vehicles have been equipped with large tanks or inflated bags which can be filled every 10 to 30 miles at gas-dispensing stations along the main highways.

The disadvantage of frequent stops for refueling can be overcome by installing miniature gas-producing plants on the vehicles themselves, and one of the larger British manufacturing companies has developed an improved gas-plant unit which is now being made and sold in large quantities, according to an article in the May, 1940, issue of *The Automobile Engineer* (Great Britain).

The improved gas-producer plant and filter system are shown diagrammatically in Fig. 9. The water is fed from a four-gallon tank past a nonreturn valve to a heating coil inserted in the gas-collecting chamber immediately above the fire bed and delivered as steam directly to a jet mounted in the base of the heat-exchange chamber. The coil functions as a flash boiler and as pressure is developed the nonreturn valve is seated and the water supply interrupted until the pressure has dropped as the result of the discharge of steam from the jet into the producer. This automatic action, it is stated, occurs several times a second. Approximately 15 per cent of the gas generated is water gas.

In the producer both updraft and cross-draft principles are employed alternately. Normal running is effected on the updraft, but for starting up or for quickened gas generation a cross-draft tuyère is now provided and brought into operation by a changeover valve at the air inlet to the producer. By this means air is admitted directly to the combustion area at high velocity, enabling the fire to be rapidly kindled and gas quickly generated. The updraft system is preferred and retained for general running as yielding more regular and economical combustion.

The main body of the generator is of fabricated sheet steel in which is cemented a cylindrical refractory lining. At the base the firebox is furnished with a large door giving access to the grate and clamped by a centrally pivoted bar secured by a large wing nut. Of heat-resisting alloy steel, the grate is suspended from its upper flange to insure an unrestricted air flow completely around the vertical bars of the bowl. Adjacent to the firebox door is a bar section which can be withdrawn, after the removal of a packing slide, to permit raking or the removal of ash or clinker and similarly a small central bar section can be lifted out of the floor of the grate. If the starting tuyère is removed, the whole grate can be withdrawn for cleaning or inspection.

The standard fuel hopper is cylindrical, but may be of any suitable diameter or shape to meet special requirements. Seated with a flanged joint on the head of the producer body, the reduced neck through which the fuel passes into the combustion chamber projects through a perforated metal ring on the top of the refractory lining. The hopper is sealed by a circular cover having a pivoted clamp bar and wing nut similar to that used on the firebox door.

From the gas producer the gas is led into a cylindrical scrubber in which the partitions are sealed on the container wall and the possibility of the gas by-passing the filtering media due to careless replacement is eliminated. Assembled on a central rod, the filter elements are arranged to telescope and after insertion in the container are adjusted by a hand nut to expand the sealing members. Both elements in this scrubber are packed with steel wool. Removal of dust from the scrubber is a quick and simple operation as the casing is swept clean by the withdrawal of the filter assembly.

From the scrubber, gas is drawn into a filter and through a solution of sodium carbonate (washing soda) in water and a filter bed of ferric oxide (rusty steel wool). In the last filter the gas passes through an oil bath and then through a pack of

porcelain rings which furnish a large wetted surface for the extraction of fine silica dust from the gas. Any oil entrained with the gas serves as an upper cylinder lubricant for the engine. The water and oil seals are automatically broken when starting or idling. During normal operation all the slots in the skirt of the filter distributor are submerged, but with reduced suction the fluid level outside the distributor falls. This exposes the ends of the longer slots and enables sufficient gas to be drawn through by by-passing the fluid.

As a usual practice, starting up is effected by running the engine on gasoline. A torch is applied through the tuyère at the base of the firebox. The flame is carried through to the fuel and the fire can be kindled in considerably less than a minute. Gas generation follows immediately and the engine can be changed over from gasoline to gas in less than two minutes. When the fire is well established air admission is transferred from the cross-draft to the updraft by means of a changeover valve operated from the driver's seat. If it is necessary to avoid the use of any liquid fuel, the generator may be started up by blowing air through it by means of either a geared hand fan or an electric fan driven from the vehicle's battery.

Layout of the equipment on the vehicle will, of course, vary with the type of body and position of the driving cab. The generator and hopper, 14 in. in diameter and 53 in. high, may be mounted on the running board or it can be arranged to project through one corner of the body immediately behind the cab. In each instance the grate is readily accessible and the scrubber and filters are conveniently hung below the body, either before or behind the rear wheels. According to the layout on the vehicle the complete weight of the unit varies from 250 to 300 lb. Typical installations on three-ton trucks, it is stated, operate on one lb of fuel, which may be anthracite coal, coke, or charcoal. The effective range of the vehicle on a single charge will vary depending on the type of fuel employed. Since the standard hopper will hold from 40 to 70 lb of fuel, the effective mileage will also vary proportionately.

Surface Finish

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

AT Cambridge, Mass, June 5–7, 1940, as reported on page 5 of the July issue, the Massachusetts Institute of Technology conducted a Conference on Friction and Surface Finish. At the close of this Conference, O. R. Schurig, General Engineering Laboratory, General Electric Company, Schenectady, N. Y., summarized briefly some of the important points brought out. Mr. Schurig's summary follows:

The Conference included papers and discussions on (1) the preparation of surfaces, (2) observations on rubbing surfaces, and (3) the description and designation of surface characteristics. The work on lubrication is not included in this summary.

Progress has been made in the methods of preparing surfaces. A process of finishing is now used in the automotive industry for the production of smooth surfaces of core material, the procedure involving low pressure, low speed, and multimotion. Reduced clearances between moving parts have been applied consistent with improvements in trueness and smoothness of rubbing surfaces, and reduced rate of wear has been indicated. Further experience with designs of this kind will undoubtedly bring out more clearly the full significance of this development.

New data have been presented which show not only how the metal structure below the surface and its composition are affected by various finishing processes but also that the character and the depth of these effects vary widely for different finishing methods depending on the temperature attained by the surface and the pressure applied during the operations. These important studies further indicate that the behavior of surfaces in engineering applications depends not only on the geometrical shape of the surface, but also on the metallurgical changes produced below the surface by the machining and finishing processes. The results of more complete researches in these directions may have far-reaching effects not only on the selection of finishing processes for surfaces in different applications, but also on the design and performance of the surfaces.

In other presentations were reported observations relating to the behavior of rubbing surfaces under service conditions. It was pointed out that as the surface is made smoother, the initial wear rate is reduced. However, it appears that a better understanding is needed of the behavior of highly loaded surfaces and of the factors that limit the maximum load, not only from the standpoint of the metals and the lubricant used, but also from the standpoint of the surface quality.

Experience on the relative antiscore qualities of various materials for bearings was presented. A relationship between the order of merit of these materials and the Periodic Table of Elements was suggested. If a relation of this kind were further substantiated, it might lead to a clearer understanding of the fundamentals involved in the operation of different materials for bearing surfaces.

New results pertaining to the mechanism of the behavior and the operation of cutting tools were presented, indicating the importance of maintaining a contaminating film on the tool surfaces in order to reduce the roughness of the machined surface due to the "built-up edge" on the cutting tool. The principles determining the magnitude of the coefficient of friction between metals were presented in this connection. The value of these results was indicated in their application to cutting-tool operation. Moreover, this work should lead to a better understanding of the selection of metals for bearings with anti-seizing properties.

New data on the shape qualities of surfaces were presented with the aid of surface profiles cut at a shallow angle of approximately 2 deg. The value of this method of cutting is due to the lengthening of the cutting plane. If further used, taper profiles will give information of added value on surface qualities, which can be coordinated with observations on the operating performance of surfaces.

It is pointed out in this connection that much uncertainty in the interpretation of test results on the operating performance of surfaces might be cleared up if in future studies of surface behavior the surface characteristics are more fully described than has often been done in the past.

In a review of the measuring devices for determining surface quality it was pointed out that many useful instruments and measuring means are available, but that no one method alone gives an adequate measure of all the essential surface qualities. Possibly different measurement methods will need to be used in accordance with the application for which the surface is prepared.

Various methods of designating surface irregularities were also reviewed, indicating that no one numerical measure is fully descriptive of surface quality.

While surfaces have been described and numerically designated in terms of various parameters of a surface profile, it has not been clearly shown what surface qualities are important in the behavior of surfaces under different conditions, and it is therefore suggested that efforts be concentrated on determining those qualities which are significant in the behavior of surfaces, so that agreement can be reached on a basis for describing and measuring surface qualities.

[It is understood that the papers and discussions of the Conference are being published by M.I.T.—EDITOR.]

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Superpressed Plywood

COMMENT BY DON BROUSE[1]

The authors are to be complimented for being the first in this country to offer definite technical data[2] on an improved material of construction. This material has received more attention in countries where the present economic conditions require greater consideration of methods of utilizing limited domestic materials than they do here. Apparently, however, laminated stock of many thin plies, formed with or without compression, is one of those developments which may be of value to us even though it originated under conditions differing from our own.

It is somewhat difficult to offer criticism or comments on the paper because it concerns a material unfamiliar to most of us. The values the authors obtained appear to agree well with those reported by foreign investigators. We hope the same authors or others will be able to extend the experiments to cover the variables in greater detail and to add information on other properties not reported here. With respect to the test data, it is not clear how the shear values, obtained with the method indicated in Fig. 1 of the paper, could be regarded as directly comparable with the values quoted from the "Wood Handbook,"[3] which are based on notched specimens in single shear. Perhaps, however, the "Wood Handbook" figures for shearing strength parallel to the grain were listed only for information and not with the thought of being directly comparable, for it is known that the type of specimen and the amount of offset affect the results and also the shear area.

We would like to suggest, for future work, experiments to determine the effect of subsequent exposure to moisture on the density and other properties of the compressed plywood. If normal wood is crushed and later subjected to changing moisture conditions, it will regain a part of the original dimensions. Under proper conditions of treatment, particularly by impregnation with resins of the phenolic type, dimension changes that result from moisture conditions may be greatly reduced. It is assumed that a compressed wood may be formed involving such a treatment as will not regain original dimensions when subjected to moisture changes.

In the material discussed by the authors, the veneer has not been subjected to impregnation treatment and, in themselves, the veneer sheets might be expected to behave like unimpregnated compressed wood, except for the penetration of the phenolic resin during the gluing process. The penetration of moisture through the surfaces would be greatly retarded by the numerous phenolic-glue lines but moisture would still be free to penetrate the edges and follow parallel to the glue lines. It is possible that over a period of time this absorption would be sufficient to cause appreciable regain in dimensions, resulting in a decrease in density and in strength properties. It is also possible that the moisture absorption is so slow that its effects are negligible and that the material may be regarded as stable for all practical purposes. Before such assumption is made, however, experiments to establish the facts would be needed.

COMMENT BY RALPH CASSELMAN[4]

The writer believes the densified wood produced by pressing veneers at high pressure supplements importantly the materials now available. Of particular significance is the rapid increase in strength over gravity, shown by the data. This probably is the result of more intimate union of the fibers, rendering them less likely to separate, so that the true unit strength of the cellulose fiber is more closely approached.

It has been the writer's observation on panels of densified wood, pressed in the manner indicated, that press cooling is very much to be desired. Panels withdrawn at a temperature substantially above the boiling point of water are quite apt to swell in some areas, becoming quite irregular in dimension. Reliably flat panels are obtained only by cooling in the press.

The great influence of moisture content on the compressibility of the wood and its effect on the final properties cannot be too greatly emphasized. Hot, moist wood is very readily compressed, but hot, dry wood is compressed only at high pressures, and then may be severely crushed in the process, thereby reducing markedly the mechanical properties of the panel.

The use of resin film for the preparation of densified wood has very definite advantages with respect to convenience of assembly and, possibly, with respect to maintaining certain mechanical properties of the wood. The life (elasticity) of the wood is much better maintained with a minimum of penetration, such as is obtained with the resin film. The process, however, has a definite drawback with respect to the effect of moisture upon the finished panel. We have found that a panel pressed by this process at 1200 psi to approximately $^1/_2$ its thickness regained 57 per cent of its original compression upon soaking in hot water. The regain on exposure to humidity might be slower, but something on the same order must be expected. Since the fibers are not completely set in their new positions, some sort of elastic regain must also be expected. In order to avoid the elastic and moisture regain in thickness, it is necessary to impregnate the veneers with a liquid material and thoroughly bind and set the fibers. There may, of course, be applications where the regain in thickness is of little importance, as in die boards, but usually, as in propeller construction, dimensional stability is very necessary.

The cost of densified wood has always been a limitation on its commercial utilization. For instance, panels prepared in the manner described with, say, 75 sheets of $^1/_{40}$-in. veneers would have to sell for $1.25 to $1.50 per board foot. Any development leading to substantially lower costs would find enthusiastic reception.

COMMENT BY H. N. HAUT[5]

The effort to obtain certain fundamental information concerning the properties of superpressed plywood is highly com-

[1] Engineer, United States Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wis.

[2] "Superpressed Plywood," by R. K. Bernhard, Thomas D. Perry, and E. G. Stern, MECHANICAL ENGINEERING, March, 1940, pp. 189–195.

[3] "Wood Handbook," U. S. Forest Products Laboratory, Madison, Wis., 1935.

[4] Research and Development, Bakelite Corporation, Bloomfield, N. J.

[5] Chief Inspector, Bellanca Aircraft Corporation, New Castle, Del.

mendable, since the bulk of essential data on this subject to date, has come from Europe, notably England and Germany.

In general, the investigation reported in this paper, the conclusions drawn, and the results tabulated therein check rather closely with the results obtained by Kraemer, DeBruyne, and the De Havilland company's work with the British JIC process.

In evaluating superpressed plywood as a structural material, particularly in aircraft structures, as suggested by the authors, it is immediately observed that an all-over increase in physical properties follows the increase in specific gravity. However, when a constant resin content is maintained and the specific gravity is increased by virtue of pressure alone (Table 3 of the paper), the expected increase in compression strength falls far behind the increase in tensile strength. This is well illustrated by items *C*, *D*, and *E* in Table 3. The $^1/_{48}$-in. veneers indicate the same resin distribution in each case. It will be seen that, when the specific pressure is increased from 500 to 1500 psi, the ratio of compression strength to specific gravity falls from 11,000 to 10,500 while the ratio of tensile strength over specific gravity increases from 18,200 to 21,000. This tensile ratio compares very favorably with other structural materials such as duralumin and heat-treated chrome-molybdenum steel, while the compression-over-specific-gravity ratio does not.

Two factors controlling density are:

1 The specific pressure employed.

2 The amount of resin introduced into the construction either as a definite layer between veneers, as an impregnant forced or absorbed into the wood, or a combination of both.

Table 4 deals with the effect of increasing the resin content with the specific pressure held constant. While the data are not as complete as those on pressures, or sufficiently so to draw conclusions, the implications are, in the writer's opinion, of utmost importance. It appears that increasing the resin content by absorption into the wood, likewise increases considerably the ratio of compression strength over specific gravity, with but little change in the tensile-over-specific-gravity ratio. It is entirely logical to presume then, that a compromise could be effected between resin content and specific pressure to produce a well-balanced set of physical properties, comparable with other structural materials. With the film type of resin this increase could probably be accomplished only by decreasing the thickness of veneers and using double film layers, since Table 4 indicates that multiple thicknesses of film tend to build up between veneers rather than to impregnate them.

An alternative method would be to impregnate the veneers with a liquid resin by spreading, soaking, or under pressure. With this method, it is probable that veneers thicker than $^1/_{48}$ in. could be used satisfactorily.

The authors have recommended lines for further investigation of the properties of this material. In addition to these, the writer would suggest a critical evaluation of variations in the percentage of resin absorbed in the wood, together with variations in pressure and the effect of these variations on the physical properties of the construction.

Moisture absorption is another important property of this structural material. It may be considered as dependent on both resin absorption and pressure, and should be given careful consideration in further investigations involving these two variables.

COMMENT BY CHARLES B. NORRIS[6]

It is evident that an extremely useful material may be obtained by the compression of woods. Some work has been done in Europe on the process but it is evident that in this country additional information on this subject is required.

It has long been suspected that wood is held together by secondary valence forces between the cellulose and lignin of which the wood is composed. The strength of paper can be increased by running it through calenders at high pressures. This increase in strength is probably due to a compression of the cellulose crystals, causing adjacent crystals to come more thoroughly in contact and thus allow the secondary valence forces to act.

An examination of the data given by the authors shows that the strength values obtained would be expected at the densities obtained. The Forest Products Laboratory has pointed out that the compression strengths of wood should increase in direct proportion to specific gravity. It has also been pointed out that the modulus of rupture and, therefore, probably the tensile strength of wood should vary according to the $1^1/_4$ power of the specific gravity. Applying these two well-known facts to Table 3 of the authors' paper, we find their strength values in compression follow this law very closely with the exception of the value for solid woods. This value should not have been included in the table since it was taken from the data of the Forest Products Laboratory and is an average value and does not apply directly to the particular samples of wood tested by the authors. Eliminating this value, the other compression-strength figures follow the specific-gravity law with a maximum error of $3^1/_2$ per cent. The error in the figure for solid wood is about 10 per cent.

If we assume that the tensile strength varies according to the $1^1/_4$ power of the specific gravity, a similar consistency of the data is found. The greatest error is 5.3 per cent. In this case, the value for solid wood is directly in line with the values given in the table, with an error of only 2.4 per cent.

This method of analyzing the data would indicate that the increased strength properties are due primarily to the densification of the wood rather than to the adhesive used. It would be very interesting indeed to run similar experiments on solid wood, compressing the wood at least in two directions, that is, in the tangential and radial directions. We would expect that very similar results would be obtained without the use of an adhesive. It would be interesting, also, to determine the effect of first impregnating the wood with the adhesive and then pressing at various pressures.

AUTHORS' CLOSURE

It was understood that the investigations reported in the paper were to be considered as pilot tests only. The authors propose the performance of additional tests. Fundamental research is to be conducted on the following:

1 Stress distribution and moduli of elasticity in compression, tension, and bending of plywood, with a varying amount of bonding material and veneers of varying thicknesses.

2 Relation between creep and amount of glue, bonding pressure, number and thickness of the veneers, and the like.

3 Endurance limit of plywood under stress reversal, in the compression range, and in the tension range, and the effect of impact loads.

4 Hardness, moisture absorption, resistance against swelling and splitting, and inflammability of plywood.

5 Influence of impregnation with resin of the veneers before bondage on the strength and resistance against exposure.

Furthermore it is planned to perform static and dynamic tests on structural units and joints, such as:

1 Rectangular, T, channel, I, round, and tubular cross sections of various dimensions.

2 Glued, nailed or screwed, glued and nailed, glued and screwed, bolted,

[6] Director of Research, Merritt Engineering and Sales Company, Lockport, N. Y. Mem. A.S.M.E.

tooth plate connector, and ring-connector joints of various sizes.

3 Propellers, wings, and fuselages of airplanes of various sizes.

Upon performance of these investigations most of the data which are called for in the discussion will probably be available.

In the authors' opinion the resistance of superpressed plywood to exposure is based on the impregnation of the veneers due to the penetration of resin surrounding the cell walls and filling the lumen of the vessel element during bondage under high pressure. This impregnation can be regulated by the amount of resin placed between the veneers and the pressure applied during bondage. Microscopic sections through birch and poplar plywood compressed at 1000 or 1500 psi (with one layer of glue film between the veneers) showed that the plywood bonded at the higher pressure had completely impregnated cell walls and resin-filled lumens of the vessel elements of the veneers, Fig. 1. Plywood bonded at 1000 psi indicated a penetration of the $^1/_{48}$-in. veneers of approximately 50 per cent. Plywood bonded at a lower pressure than 1000 psi showed only slight impregnation of the cell walls next to the glue joints and a shallow penetration of resin between the variously arranged cells and through some of the vessels.

FIG. 1 85/48-IN. BIRCH BONDED AT 1500 PSI
(Note longitudinal shape of cells due to pressure applied during bondage; discoloration of cell walls indicated impregnation of cells with resin.)

In contrast to "superpressed wood," such as, lignostone of beech, Fig. 2, superpressed plywood does not show the interlocking of the fibers within and between the veneers and the complete disappearance of the tracheary elements. The alternate arrangement of the thin veneers ($^1/_{48}$-in.) prevents the interlocking effect which otherwise would make unnecessary the use of any bonding material as long as the plywood is only under compression.

In order to make possible a comparison between untreated wood, compressed in two directions (tangentially and radially) and resin-bonded superpressed plywood, compressed in one direction only (Table 6 of the paper), Fig. 3 is presented. The compression values for both materials are indicated. It should be noted that different woods were used for the compressed wood and plywood. However, as indicated in Table 2 of the paper, the variation in strength of the materials, bonded under high specific pressure, can be disregarded. Because of the fact that in plywood one half of the wood is in compression parallel and one half in compression perpendicular to the grain, the values of superpressed plywood represent intermediate data as indicated by the test results. Additional test data may prove that the

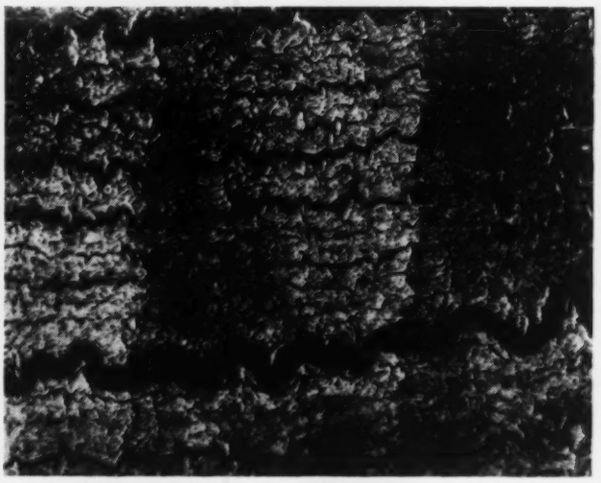


FIG. 2 BEECH COMPRESSED TANGENTIALLY AND RADIALLY AT 4500 PSI
(Note interlocking effect of cell walls.)

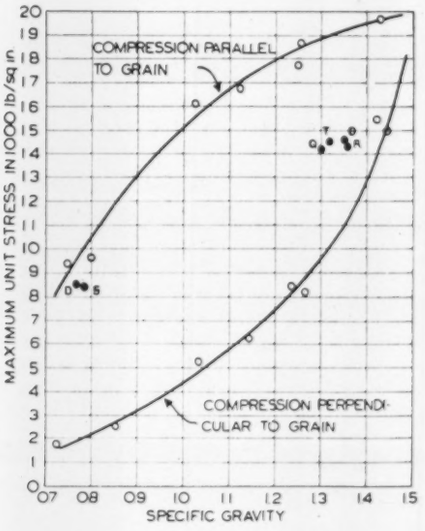


FIG. 3 COMPRESSIVE STRESSES IN RELATION TO SPECIFIC GRAVITY OF UNTREATED WOOD COMPRESSED IN TWO DIRECTIONS AND RESIN-BONDED SUPERPRESSED PLYWOOD COMPRESSED IN ONE DIRECTION
(● Resin-bonded superpressed plywood, compressed in one direction. O Data for compressed beech or lignostone, according to O. Graf.[7])

[7] "Über die Ermittlung der mechanischen Eigenschaften der Hölzer und über Abnahmevorschriften," by O. Graf, *Mitteilungen Fachausschuss für Holzfragen*, no. 4, Berlin, 1932.

comparison of these values can be accepted. Thus, the adhesive increases the compressive strength of the material of lower specific gravity and is of no benefit for the compressive strength of plywood of high specific gravity. It is evident that this comparison of superpressed wood and plywood will not hold true for other than compression tests.

A new bonding procedure has been suggested (*Bautechnik*, March 3, 1938) in order (1) to assure a lower cost of superpressed plywood by decreasing the necessary time of bonding (seven to ten times); (2) to increase the strength of the material; and (3) to be more independent of the moisture content of the veneers during bonding.

Instead of the paper film which hitherto has been serving the purpose of a glue carrier, glue-covered fine soft-copper-wire mesh of nine $^1/_{64}$-in-diam wires per in. is inserted between the veneers. The temperature necessary for the hot-gluing procedure can be produced in the glue plane by electric currents instead of the transmission of heat from platens through the numerous wood layers. However, no detailed data are available on this procedure and, particularly, on possible difficulties in cutting the material.

The authors appreciate greatly the valuable comments made. No doubt can remain that a substantial number of tests will have to be made before definite conclusions may be drawn.

R. K. BERNHARD.[8]
T. D. PERRY.[9]
E. G. STERN.[10]

Pulverized-Coal Firing[11]

COMMENT BY O. F. CAMPBELL[12]

It is the writer's belief that, other than the grindability index of coal, it is doubted that other coal characteristics have a great deal of bearing upon pulverized-coal firing. If the coal has a low grindability and pulverization is poor, there is no doubt but that operating difficulties will occur due to coarse pulverization. It is the writer's opinion that burner design has more influence on pulverized-coal firing than any single factor. The pulverized-coal-burner manufacturers are challenged to design a better burner which will give the proper air-fuel-mixing characteristic that is essential to the better burning of pulverized coal.

Petroleum coke has been cited as an example of a representative type of solid fuel to be burned in pulverized form. Pulverized petroleum coke having a high grindability usually contains an appreciable amount of volatile-matter content and is somewhat oily. It is this oiliness characteristic which has a tendency to produce the agglutination, mentioned by the author. It has been the writer's experience that it is possible, with the proper burner design, to burn pulverized-petroleum coke having volatile-matter content as low as 5 per cent and less than 0.5 per cent ash in water-cooled furnaces without auxiliary fuel of any kind. Under these conditions, it is essential that pulverization be exceptionally good. This would indicate that proper burner design is essential for the burning of any pulverized solid fuel.

COMMENT BY R. A. SHERMAN[13]

In this paper the author has given a simple and clear explanation of the relation of the characteristics of coals to their use in pulverized firing as we know it at present. By relating the favorable and unfavorable characteristics of coals to their rapid, complete, and trouble-free burning, he has in effect set up a balance with two arms and has told us on which arm each of the characteristics should be placed. To this extent, the paper is helpful. However, he failed, and others would fail also, because the information is lacking, to state the point on each arm at which each characteristic should be placed. One cannot tell, even if he has all of the characteristics properly measured, in which direction the pointer of the balance will register. That is, knowing all of these characteristics of several coals, one cannot properly evaluate them for pulverized firing without burning tests.

Furthermore, we do not yet have standard methods for the determination of two of the characteristics, agglutination and swelling. A method for determination of the agglutinating index has been proposed by Committee D-5 of the A.S.T.M. but because of difficulties in obtaining check results by various laboratories it has not yet been set up even as a "Tentative Standard." The writer would question whether the agglutinating index of a coal is of great importance in pulverized firing although he will agree to its importance in combustion in fuel beds. When coal is suspended in air, it is possible that the oxidation of the surface so rapidly modifies the agglutinating tendencies that the particles do not agglomerate. In the spreader stoker, for example, the caking of coal does not occur to the extent that it does in firing on underfeed stokers.

The British Standard Crucible Swelling Test for Coal is receiving considerable attention at present in this country and has been shown to be of value in predicting the performance on underfeed stokers. The writer has no information correlating it to pulverized firing but understands that some is being obtained.

Two characteristics which we should know concerning a coal that is to be burned in pulverized form are (1) the rate of ignition and (2) the rate of burning of the carbon remaining after the volatile is driven off and burned. The writer suggests that these be set up as separate characteristics and an attempt be made to find measures for them. If we assume that the mechanism of burning is the initial rapid distillation of the volatile matter followed by the combustion of the carbon, the two characteristics may not be related. A given coal might ignite rapidly or at a low temperature but the carbon might burn slowly. Quick ignition would mean, however, that a longer time would be available for combustion of the carbon and a lower carbon loss would result.

Subcommittee XVI on Ignitibility of Coal and Coke of Committee D-5 of the A.S.T.M. has recognized that the ignitibility of a fuel is so likely to be affected by the physical characteristics of the fuel and the surroundings that a fuel cannot be considered to have an ignition temperature which is an independent characteristic. They believe, however, that the temperature at which a fuel attains a given rate of oxidation under standard conditions may be a useful criterion of the performance of the fuel.

A few data on the ignition temperature of pulverized coals following this concept and by substantially the method described by Sebastian and Mayers[14] were included in a report submitted by Battelle to this Subcommittee at the Detroit meeting of the A.S.T.M., March 4, 1940.

The accompanying Table 1 presents

[8] Professor and Head of the Department of Engineering Mechanics, The Pennsylvania State College, State College, Pa.

[9] Woodworking Engineer in charge of Market Development, The Resinous Products and Chemical Company, Philadelphia, Pa. Mem. A.S.M.E.

[10] Registered Architect, Research Assistant for the Department of Engineering Mechanics, The Pennsylvania State College, State College, Pa.

[11] "Effect of Coal Characteristics on Pulverized-Coal Firing," by Ollison Craig, MECHANICAL ENGINEERING, June, 1940, pp. 452–454.

[12] Combustion Engineer, Sinclair Refining Company, East Chicago, Ind. Mem. A.S.M.E.

[13] Supervisor, Fuels Division, Battelle Memorial Institute, Columbus, Ohio. Mem. A.S.M.E.

[14] "Coke Reactivity Determination by a Modified Ignition Point Method," by J. J. S. Sebastian and M. A. Mayers, Contribution 59, Coal Research Laboratory, Carnegie Institute of Technology, Oct., 1937, from *Industrial and Engineering Chemistry*, vol. 29, 1937, p. 1118.

IGNITION TEMPERATURES OF THREE PULVERIZED COALS

Coal seam	Through 200 mesh, per cent	Moisture, per cent	Ash, per cent	Volatile, moisture- and ash-free, per cent	Ignition temperature, deg F	
					Pulv	—40 + 60 M
C Prime	75.0	0.2	7.0	18.9	446	562
Taggart	68.6	0.3	2.9	34.8	416	515
Ill. No. 6	66.8	6.2	12.1	44.9	360	374

values on the three coals for what is essentially the ignition temperature in air. The coals were pulverized in a ball mill and had been burned in a related investigation in the experimental furnace at Battelle at rates of 200 lb per hr.

Two items of interest may be noted in this tabulation:

1 The ignition temperatures are in the order which would be expected from the observed appearance of the flame at the face of the burner and from the rate of burning as indicated by the rise in the temperature in the pat of the flame. The C Prime coal ignited at some distance away from the burner, the Taggart coal closer, and the Illinois coal started to burn immediately at the face of the burner. There was a greater difference in the ignition temperatures of the Taggart and Illinois coals than between the Taggart and C Prime coals, despite the wider spread of the volatile-matter content and the high ash content of the Illinois coal.

2 The difference between the ignition temperature of the pulverized coal and the —40 +60 mesh coal is very small for the Illinois coal, compared to those for the other two coals. The determinations were made on the —40 +60 mesh size as well as the pulverized coal because Sebastian and Mayers in their early work had adopted that as standard. An obvious defect of this size is that it is not representative of the coal; more than half of the sample must be discarded in the preparation of this size.

The practical significance of the similarity of the ignition temperatures of the two sizes of Illinois coal is that this coal does not need to be pulverized finely to obtain quick ignition. This corresponds with the statements made by the author on Midwestern coals.

COMMENT BY A. W. THORSON[15]

The author's remarks concerning the effect of swelling and coking properties of coal when fired in pulverized form are extremely interesting. It is generally believed by coal consumers that these properties have little influence upon combustion when firing pulverized coal.

It is known from research that different types of coke are produced by varying the rate of heating of coal and that the cokes formed from various coals have rates of reactivity which do not correlate with the coking or free-burning tendencies of the original coals. In other words, the author has touched upon a problem deserving of much additional study.

The effect of coal properties and other factors upon the combustible remaining in the cinder and fly ash is another interesting problem. Studies indicate that operating conditions remaining constant, combustible in the refuse decreases with increasing volatile matter and with increasing ash content. This is to be expected when one considers that the unburned combustible results from the fixed carbon which decreases as the percentage of volatile matter increases; and when one considers that, above a certain minimum value, any additional ash content is mainly extraneous matter not intimately mixed with the coal, thereby merely diluting the unburned carbon and reducing its percentage in the mixture.

The author aptly reviews the design requirements for burning high-volatile versus low-volatile coals. Too often, but little thought is given to the difference in fundamental requirements when considering change from one to the other type of fuel. It is hoped that the paper will stimulate more conclusive effort in that direction.

AUTHOR'S CLOSURE

The author of course cannot agree with Mr. Campbell that grindability index is the only characteristic having any bearing upon pulverized-coal firing. If such were the case, there would be no purpose in the paper. Also, the contrary is proved by many years' experience of many people. Nor does he agree with Mr. Campbell that there is room for improvement in burner design. The effect of such improvement will not be to eliminate the differences in effects of the various coal characteristics, but merely to lessen these differences.

Mr. Sherman is correct in stating the paper points only to the direction in which various characteristics produce an effect without giving the magnitude. The magnitudes cannot be stated with any degree of accuracy, not only through lack of knowledge, but also because these magnitudes are different in different installations. Mr. Sherman has kindly contributed data and information throwing additional light on the subject.

Mr. Thorson has indicated that the coke remaining after volatile distillation from the same coal may burn at different rates in different furnaces, depending upon the rate at which the coal is heated when introduced into the furnace. As far as the author knows, this has never been given any study in powdered-coal firing and undoubtedly is worthy of further attention.

In the preparation of this paper, it was not the intention to indicate that any one type of coal was more suitable for pulverized-coal firing than another, but rather to point out the things which should be done more nearly to equalize results to be obtained from all coals.

OLLISON CRAIG.[16]

Factors in the Fatigue of Helical Springs[17]

COMMENT BY JOHN M. LESSELLS[18]

Being interested in the valve-spring problem, the writer has made an analysis of the results of this paper, based on

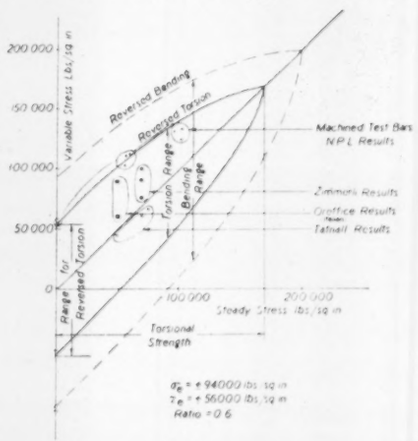


FIG. 1 TENSILE AND ENDURANCE LIMITS OF SPRING WIRE IN BENDING

known fatigue data. This has been difficult of accomplishment, because the author has supplied little or no information on the mechanical properties of the wire used.

Based on the data published by Zimmerli[19] for the tensile and endurance

[15] The Chesapeake and Ohio Railway Company, Detroit, Mich. Mem. A.S.M.E.

[16] Engineering Manager, Riley Stoker Corporation, Worcester, Mass. Mem. A.S.M.E.

[17] "Factors in the Fatigue of Helical Springs," by R. R. Tatnall, MECHANICAL ENGINEERING, April, 1940, pp. 289–292.

[18] Associate Professor of Mechanical Engineering, The Massachusetts Institute of Technology, Cambridge, Mass. Mem. A.S.M.E.

[19] "Permissible Stress Ranges for Small Helical Springs," by F. K. Zimmerli, Department of Engineering Research, University of Michigan, Bulletin No. 26, 1934.

limit in bending for spring wire of the dimensions considered, a plot is obtained as in Fig. 1 of this discussion, in which the ordinate represents a variable stress and the abscissa the steady stress. Knowing the torsional strength of the material and a suitable ratio for the strengths in tension and torsion, a derived curve may be obtained as indicated. It is of interest to note that the results obtained on machined test bars by the National Physical Laboratory,[20] when tested under cyclic mean stresses, fall fairly well on such a curve as indicated. Possibly this curve as derived represents fairly well the maximum range of stresses which can be expected from spring material.

On this basis it is of interest to superimpose the results obtained by the author and others on safe stress ranges for helical springs. The author's results indicate considerably smaller stress ranges than found by Zimmerli, and his results again are smaller than may be expected for machined bars.

The writer appreciates that surface and any slight decarburization effects must contribute to a decrease in the stress ranges obtained for machined test bars but presents this information in the hope that more light will be thrown on this spring problem.

COMMENT BY S. N. MCCASLIN[21]

The author has clearly combined certain well-known factors in the design of a spring to produce, in Fig. 6 of the paper, a stress range which should be satisfactory so that no fatigue failure would result. However, it is generally recognized among spring manufacturers that the variations in the physical properties can reduce the fatigue life of the spring almost to zero. In other words, Fig. 4 of the paper is the result apparently of laboratory tests on springs with first-class-quality wire in them.

May we suggest the following procedure for the spring designer who, under normal manufacturing conditions, wishes to overcome failure from fatigue:

1 Proceed as indicated in Fig. 3 of the paper.

2 Using a twist and bend test, determine by experimentation the minimum amount of twist and number of bends the spring wire must stand to meet the normal operating load.

We believe that the chart shown in Fig. 3, together with experimental data developed for the wire manufactured constitute more practicable information than Fig. 4 or Fig. 5 of the paper.

It is desirable to emphasize the fact that, beyond the regular spring formula plus the two corrective factors, namely, those of curvature and direct shear, as established by A. M. Wahl, and the induced-vibration factor, as established by studies of Den Hartog, the actual physical properties of the wire in question, as tested by simple physical means, are most important when considering factors in the fatigue of helical springs.

Furthermore, the method of supporting a helical spring has a decided bearing on its fatigue life. If the spring is supported by a rod through the center, with nuts and washers attached to the rod, or if it is supported in pockets, or in a tube, the effect of the shape, the material, and the amount of wear these supporting elements have on the spring is important from a fatigue-failure standpoint. Recently, we have seen the failure of an alloy-spring wire, which was overcome by using a wire, having lower physical properties and a lower endurance limit but which in operation withstood the wear of the supporting machine element better, and therefore did not fail from fatigue.

COMMENT BY W. R. SPILLER[22]

In the discussion contained in this paper on the phenomenon of vibration of helical coil springs, it is noted that extreme vibration always occurs at some whole fraction of the natural frequency of the spring. Further, it is stated that "for some obscure reason, this does not occur at every resonant speed, but it can and does take place in many instances." This peculiarity was noted and was the occasion for considerable work done at the research laboratory of the White Motor Company a number of years ago in connection with valve springs. At that time it was found that the intensity of vibration at any resonant speed was in direct relation to the corresponding harmonic of the periodic actuating force. In this case, a harmonic analysis of the valve-lift curve provided the values of the various harmonics and coincided very closely with actual measurements of the amplitude of vibration, when measured experimentally on a machine expressly designed for this purpose. Further information may be found in an article[23] by F. Jehle and W. R. Spiller.

COMMENT BY J. K. WOOD[24]

As chairman of the special A.S.M.E. Research Committee on Mechanical Springs about a decade ago, the writer particularly emphasized the great need of adequate fatigue data on spring wire or bar stock in the coiled and uncoiled states, and was largely instrumental in engaging the active interest of Dr. D. J. McAdams in the latter phase of this problem.

Specifically, the following example of the practical advantage of the graphical method of comparing the "range of endurance limit" and the "true working cycle" of the spring, might be cited. In recent years the writer has devoted considerable time to the study of the proper suspension of high-temperature piping which up to a few years ago was accomplished almost entirely by means of hangers employing helical compression springs. In a lecture on this subject delivered on March 14, 1940, at the United States Naval Academy, Annapolis, Md., and subsequently repeated before the Metropolitan Section of the A.S.M.E. in New York City, the writer showed that, in order to obtain the maximum protection against the increase of pipe-wall stress due solely to weight transfer from the hangers to the pipe, the percentage variability of the spring must be kept as small as possible. The percentage variability of the spring, which was designated by the letter V, is equal to the reciprocal of the deflection corresponding to the actual weight of the pipe initially supported by the hanger multiplied by 100. In practice a 20 per cent variability would mean that the supporting force of the hanger from which a 1000-lb weight of pipe is hung would change ±200 lb for every inch of travel due to thermal expansion.

In order to show the relation of this principal requirement to the design factors of the spring, the "spring-service diagram" shown in Fig. 2 of this discussion was used. The maximum or safe solid deflection is F and the normal working deflection is $F/2$ which gives a percentage variability factor of V equal to $200/F$. A load-adjustment range of ±20 per cent is allowed for commercial variations both in pipe weight and load-deflection rate of the spring. Since the direction of the thermal travel of the pipe may be such as either to compress the spring further or to release it partly, the travel, represented by T, is placed on either side of the "normal working height." Superimposed on either of these spring heights is the vibration

[20] "Mechanical Testing," by R. A. Batson and J. H. Hyde, vol. 1, second edition, Chapman and Hall, London, 1931.

[21] Crompton & Knowles Loom Works, Worcester, Mass.

[22] Chief Engineer, Seybold Division, Harris, Seybold, Potter Company, Dayton, Ohio.

[23] "Idiosyncracies of Valve Mechanisms and Their Causes," by F. Jehle and W. R. Spiller, Trans. Society of Automotive Engineers, vol. 24, 1929, pp. 197–207.

[24] Chief Engineer, General Spring Corporation, New York, N. Y. Mem. A.S.M.E.

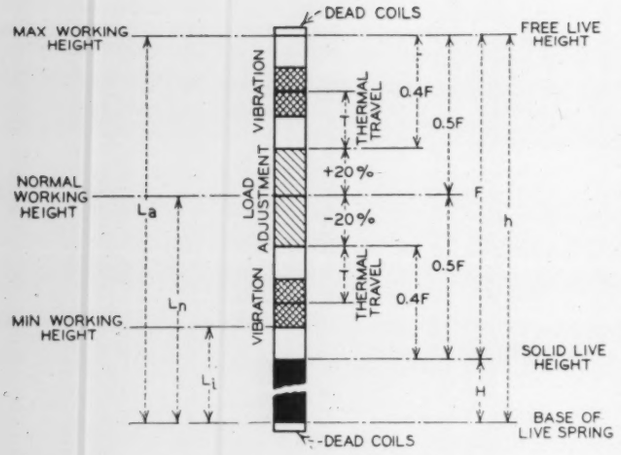


FIG. 2 SPRING-SERVICE DIAGRAM

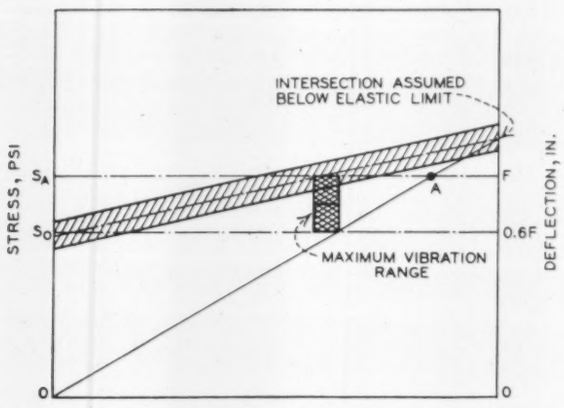


FIG. 3 MAXIMUM VIBRATION RANGE SUPERIMPOSED ON RANGE-OF-ENDURANCE-LIMIT DIAGRAM

range in case one exists. The minimum and maximum working heights are determined by the outer ends of the vibrational ranges.

The amplitude of the vibration range will depend upon the ratio of the frequency of the impressed vibration to the natural frequency of the spring, the amplitude of the impressed vibration, and the damping factor of the system. If the ratio of the two frequencies is equal or close in value to unity, resonance will occur which, if the damping factor is small, will produce a prohibitive amplitude. In general, the natural frequency of a spring in number of vibrations per minute is given by

$$\text{Natural frequency} = \frac{30\sqrt{g}}{\pi}\sqrt{\frac{i\,k_s}{i\,R^2W + w}} \quad \ldots\ldots\ldots[1]$$

in which k_s = load-deflection rate in lb per in.; W = weight of pipe in lb; w = weight of spring; i = equivalent mass factor, depending upon the mode of vibration, a pure number; R = gyration factor, which in pipe hangers is equal to unity; and g = acceleration of gravity or 386 in. per sec per sec.

Since w is small with respect to W it may be considered equal to zero. Also k_s equals $WV/100$ and i for the fundamental mode equals $4\pi^2$. Making these substitutions we have

$$\text{Natural frequency} = 18.75\sqrt{V} \quad \ldots\ldots[2]$$

Assuming a state of nonresonance and a maximum vibration range equal to 0.4 F, it is possible to determine the safe maximum working stress. Since deflection is directly proportional to actual stress, we can superimpose the maximum vibration range on the "range-of-endurance-limit" diagram in the manner outlined in the paper. We thus have the result shown in Fig. 3. Point A represents the case of no vibration. It is suggested,

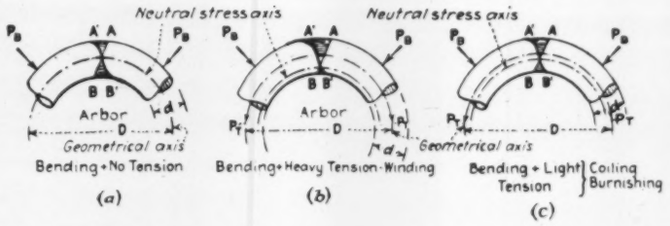


FIG. 4 (*a*) STRESSES PRODUCED BY PURE BENDING, NO TENSION AS IN HOT-WINDING; (*b*) STRESSES PRODUCED BY BENDING AND HEAVY TENSION, AS IN COLD-WINDING; (*c*) STRESSES PRODUCED BY BENDING AND LIGHT TENSION, AS IN EXTERNAL COILING OR BURNISHING

however, that the endurance limit corresponding to a minimum stress of zero be used as the safe maximum stress, which means a factor of safety equal to S_A/S_0.

Uneven distribution of load among the live coils of a helical spring during vibration has also been observed by the writer. It is a well-known fact that this occurs at certain speeds in automotive valve springs.

For safety in spring design the spring criterion should be equal to or less than the material index, that is

$$\frac{h - H}{H} \times \frac{1}{C^2} \leqq \frac{4\pi}{5} \times \frac{S_A}{G} \quad \ldots\ldots[3]$$

in which C the spring index = D/d, D being the mean diameter of the spring and d the bar diameter, both expressed in inches.

For pipe hangers a spring index of 6 is most satisfactory; a value greater than this tends toward buckling and a lesser value produces severe curvature effects. The factor $^4/_5$ is the correction for a curvature corresponding to this index.

Taking S_A = 82,000 psi and G = 11,500,000 psi, we obtain 65 per cent of the solid height H, as the safe maximum or solid compression F. Thus, the safe maximum vibration range is equal to 0.4 F or 26 per cent of H.

In the manufacture of helical springs, whether of the torsionally or axially loaded types, the various methods of forming produce entirely different stress patterns which, in spite of stress-relieving processes, may influence fatigue results appreciably. For example, cold-winding on an arbor requires the combination of tension and bending forces which displaces the neutral plane toward the center of the coil diameter as shown in Fig. 4 (*b*). Cold-coiling or burnishing externally by rollers requires relatively slight tension and, consequently, the neutral plane is not displaced to any great extent as shown in Fig. 4 (*c*). On the other hand hot-winding on an arbor produces practically no displacement of the neutral plane as is shown in Fig. 4 (*a*).

The effect of displacing the neutral plane toward the center of the coil diameter is to increase the tensile stress on the outside and decrease the compressive stress on the inside of the coil. The resulting trapped stresses may or may not be relieved by any subsequent temperature-relieving process.

Now, when the spring is in operation, the maximum stress (in this case within the elastic limit of the material) is greatest on the inside of the coil, due to the curvature of the bar. In the case of helical compression springs this was first pointed out by Rover in 1912 and later confirmed experimentally by Wahl. In helical torsional springs, the curvature correction was first derived by the

writer, but so far no knowledge of any experimental confirmation has come to his attention.

Thus the forming stresses in manufacturing and the operating stresses, in the former case exceeding the elastic limit and in the latter case not exceeding it, combine to form a complicated stress pattern, depending upon the method of forming and the spring index (ratio of spring to wire diameters). All this combined with a few other factors not mentioned have a great effect on fatigue data obtained on springs.

AUTHOR'S CLOSURE

In response to Mr. Lessells' and Mr. McCaslin's comments, the endurance limit shown in the illustrations of the paper resulted from the testing of a common grade of oil-tempered wire. It was not the purpose to discuss the properties of various materials available to the industry, but rather to outline a method by which existing and future spring designs might be checked for probable performance. If any detail of properties of various materials had been given, it could have been readily shown that the endurance limit of the best grade of wire, for example, was about 50 per cent higher than that shown in Fig. 4 of the paper, for the ordinary commercial grade.

We have found that there is no dependable relation between twist or bend tests and endurance properties. Both twist and bend are tests of ductility which automatically average the characteristics of the cross section put under stress. The fatigue test, on the other hand, is a combination of a test for ductility (in the sense of notch sensitivity), and strength (in resisting stress). Further than that, it is microscopic in character, the test result showing the properties of individual grains, or perhaps molecules, instead of the average of the cross section.

To apply rigid tests for twist and bend, properties which increase, to be sure, with the fatigue quality, is simply to step from one grade of wire to another. This can be done, of course, and the analysis outlined in the paper provides the knowledge to determine when it may be necessary to take such a step.

The manner in which the spring is supported is a most important element in spring fatigue. Serious wear, cramping or distortion can contribute to early failure. In extension springs, the type of hook or fastening has an important bearing on the spring life. The conventional hook, turned up integrally with the body of the coil, is the weakest type of fastening. Screw plugs, a coned end over a separate bolt or hook, or a separate U hook inserted through body coils, all are preferable from the fatigue point of view.

In general, our experience in vibration coincides with Mr. Spiller's comment that "the intensity of vibration. . . .was in direct relation to the corresponding harmonic. . . ." In our work with valve springs, the intensity of vibration increased with the harmonic up to the limit of solid compression of adjacent coils. However, in many designs of spring, vibration was noted at $^1/_9$, $^1/_{10}$, $^1/_{12}$, etc., of the natural frequency of the spring. There should have been a critical speed at $^1/_{11}$, but for some obscure reason, vibration was so slight as to escape detection.

Mr. Wood's discussion shows an excellent example of the application of this method of studying spring designs. In his fatigue diagram Fig. 3, the assumption that the limit lines intersect below the elastic limit is open to criticism. It is more likely that the intersection is at the value for ultimate torsional strength, described by Zimmerli in the reference[3] cited by Mr. Lessells. Even this is open to question, since many of our test results do not bear this out.

The author wishes to express his appreciation to the discussers for their interesting and pertinent comments and to express the hope that further contributions may be forthcoming on many of these topics which are in need of clarification.

R. R. TATNALL.[25]

Calculation of Helical Compression Springs

COMMENT BY I. OPATOWSKI[26]

IN the May, 1940, issue of the Transactions of the A.S.M.E. a thorough study by H. C. Keysor on helical springs compressed between two parallel planes was published. In that paper the quantities concerning the elastic behavior of the spring (which is supposed to have closed and squared tapered ends) are calculated in terms of two angles: An angle $2u$ between tip contact points; and an angle v between a tip contact point and the point where the spring bar makes contact with the corresponding loading plane.

v is related to u by a complicated trigonometric equation. The calculations of Keysor show that for round steel bars v is $=\pi - w$, where w is a small angle less than 10 deg for springs of at least $1^1/_2$ turns and less than 22 deg for shorter springs. This interesting result of Keysor may be used to deduce a very simple formula for v. In fact, the equation[27] for v contains some trigonometric functions of v, which due to the fact that w is small, may be substituted as follows

$$\sin v \approx w; \sin(u - v) \approx -\sin u - w\cos u; \quad \cos(u - v) \approx w\sin u - \cos u \ldots\ldots [1]$$

These formulas are based upon the relations $\sin w \approx w$, $\cos w \approx 1$, which are practically exact for $w < 10$ deg (springs with at least $1^1/_2$ turns) and are well approximated for short springs ($w = 22$ deg). If formulas [1] are introduced in Keysor's equation[27] for v and the terms in w^2 are neglected, the following formula is obtained

$$w = \frac{0.09\sin^2 u + 1.094\sin 2u}{2.691\sin^2 u + \sin 2u - 0.697u} \ldots [2]$$

where u and w are in radians. To check the approximation of formula [2], let us take the case where one should expect a large error: the case of maximum w which occurs for $u = 300$ deg. Equation [2] then gives $w = 20$ deg 11 min, e.g., $v = 159$ deg 49 min, whereas the value calculated by Keysor[28] was 158 deg. The difference between these two values of v is without practical importance.

Formula [2] is very useful because of its accuracy and its simplicity as compared with the method of Keysor described in his paper.

AUTHOR'S COMMENT

Mr. Opatowski's simplified approximate formula for the angle v will obviously reduce the labor of calculation. However, a series of v values need only be calculated once in order to establish the laws of variation for load eccentricity and inactive end turns. In other words, it is an investigatory calculation and not a practical working calculation. Therefore, the author decided to carry it out in the unshortened form as indicated in his paper with the idea that the fewer approximations the better, in a mathematical investigation. He is grateful to Mr. Opatowski for his comments and wishes to say that his Equation [2] is a valuable addition to his paper.

H. C. KEYSOR.[29]

[25] Metallurgical Engineer, Wickwire Spencer Steel Company, Worcester, Mass.

[26] Instructor in Mathematics and Mechanics, University of Minnesota, Minneapolis, Minn. Mem. A.S.M.E.

[27] "Calculation of the Elastic Curve of a Helical Compression Spring," by H. C. Keysor, Trans. A.S.M.E., vol. 62, 1940, p. 322, Equation [9].

[28] The writer is indebted to Mr. Keysor for the communication of these values.

[29] Mechanical Engineer, American Steel Foundries, Chicago, Ill.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Boiler Operator's Guide

BOILER OPERATOR'S GUIDE. By H. M. Spring, Jr. McGraw-Hill Book Co., Inc., New York, N. Y., 1940. Cloth, 6 × 9 in., 353 pp., $3.

REVIEWED BY C. W. OBERT

THIS volume is devoted to the construction, operation, inspection, and maintenance of steam boilers, a subject that has received but sparing consideration in the literature during the last few years. The steam-generating unit is admittedly one of the most important elements in the power plant and it merits the most careful and thoughtful treatment if efficiency in operating results is expected. As a plant unit it is capable of paying handsome dividends in return for careful attention devoted originally to design and subsequently to operation.

In this volume the author has recorded the present state of development of the art in a volume that treats of the fabricating shop practices, plant operation, inspection procedures, and maintenance requirements of steam-generating units. It has apparently been his purpose to produce a modern handbook on this specialized subject which concentrates its attention upon boilers and boiler equipment and thus enables the various phases of the subject to be adequately covered. He has performed a commendable undertaking and the volume contains a large amount of up-to-date information that will undoubtedly be welcomed by those interested in this field either from the construction or the operation viewpoint.

It is the expectation of the author as expressed in the preface that the chapters in the volume devoted to construction will be of interest to cadet boiler inspectors, to operating engineers interested in license examinations, and to anyone who wishes to know more of standard shop practices in boilermaking. With this end in view the author has devoted the major part of the construction chapters to the shop practices that are followed in the modern boiler-fabricating shops, including copious references to the modern welding fabrication procedures and methods.

Inasmuch as this volume has been written also for the benefit of the boiler operator, considerable space is devoted to the design and characteristic features of a wide variety of boilers, ranging from the more common fire-tube types up to the outstanding designs of high-pressure steam generators that have been developed and used both in this country and abroad. Some of the new types of special-service boilers are also described. These chapters are supplemented by references to the boiler appliances and auxiliaries that are necessary for safe and economical boiler operation, and their operation is discussed in detail.

The text has been made sufficiently technical to cover the important and essential elements, but is in most parts nontechnical to permit the beginner to understand and obtain benefit from the information contained thereon. For the assistance of those who are called upon to pass examinations for operators' and inspectors' licenses there are questions and answers at the end of many of the chapters which are based on the more common types of boilers and plant equipment as described in certain of the key chapters. These questions and answers are typical of those asked in many of the examinations including even some of the "trick" questions that are submitted to make sure that the applicants have the necessary practical background.

A valuable feature of the volume is to be noted in the group of appendixes which cover important supplementary studies that should be of value to the reader for reference purposes. The first appendix contains a glossary of boiler terms, while the second contains a general statement concerning the production of the materials commonly used in the construction of boiler shells and drums; an error is noted in this appendix in that a typical blast furnace is illustrated and described as a Bessemer converter. The third appendix contains information about boiler scale and the treatment of feedwater for its prevention. The fourth appendix gives a clear and lucid explanation of the preferred methods of applying patches to riveted boilers, methods which are in harmony with the latest requirements issued by the National Board of Boiler and Pressure Vessel Inspectors. The fifth appendix contains a comprehensive statement of safety rules that should always be observed in boiler operation.

While the text of the volume has been based quite definitely on American practice, the author has departed in two instances from common usage of terms that have long been established in this country. He has in several statements referred to what is called in the A.S.M.E. Boiler Construction Code the "blow-off" connection by the term "blowdown;" these references are to "blow-off" fittings, flanges, valves, and cocks in all of which they are described as "blowdown" fittings and connections. The other example of departure from customary usage is to be noted in the references in the text to what is called in the A.S.M.E. Boiler Construction Code the "blowdown" function of safety valves by use of the term "blowback;" these include the "blowdown" ring and adjustment, both of which are described as "blowback" functions.

Books Received in Library

AIRCRAFT MAINTENANCE. By D. J. Brimm and H. E. Boggess. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1940. Cloth, 6 × 9½ in., 492 pp., illus., diagrams, charts, tables, $2.50. This is a thoroughly revised edition of "Airplane and Engine Maintenance," from which the maintenance of engines has been omitted and space formerly devoted to that subject has been used for additional matter on the airplane itself. The book is designed for use by airplane mechanics as a text for home study or use in secondary schools, and for reference purposes. It presents a practical course, covering woodwork, metal work, fabric work, rigging, handling, and maintenance. The various jobs to be done are set forth with detailed directions for doing them.

AIRPLANE DESIGN. By K. D. Wood. Fourth edition, published by the author at Purdue University, Lafayette, Indiana; distributed by Cornell Co-Op Society, Ithaca, N. Y., 1939. Chapters paged separately. Stiff paper, 8½ × 11 in., illus., diagrams, charts, tables, mimeographed, $4. This book aims to show how an airplane can be designed. The following topics are covered: Layout; load factors; materials and construction; costs; the design of wings, control surfaces, landing gear, the fuselage, hulls, and floats, including stress analysis; drafting procedure; and detail design. A large appendix contains most of the data necessary to carry a design project through its preliminary stages.

This is the fourth of frequent editions which have kept up with a rapidly changing industry.

AMERICAN SOCIETY FOR TESTING MATERIALS, Proceedings of the Forty-Second Annual Meeting held at Atlantic City, N. J., June 26–30, 1939, vol. 39. American Society for Testing Materials, Philadelphia, Pa., 1940. Cloth, 6 × 9 in., 1344 pp., illus., diagrams, charts, tables, $6 to A.S.T.M. members, $9 to nonmembers. As usual, this large volume contains the summary of the proceedings at the annual meeting, the reports of the various committees, and the technical papers with the discussions.

APPLIED MECHANICS. By A. P. Poorman. Fourth edition. McGraw-Hill Book Co., Inc., New York, N. Y., 1940. Cloth, 6 × 9½ in., 354 pp., diagrams, charts, tables, $2.75. In the new edition of this standard textbook certain material has been rearranged for purposes of simplicity or better continuity, and some new material has been added on moment of inertia of mass. The data of all problems have been made new, and many problems have been added, all the numerical answers being given as before. The subject matter covers both statics and dynamics.

BIBLIOGRAPHY ON INDUSTRIAL RADIOGRAPHY, including Addenda I, April, 1940. Document 1139. By H. R. Isenburger. American Documentation Institute, Washington, D.C. Paper, 6 × 8 in., photographic copies, $10.70. This bibliography contains references to over two hundred articles on the industrial uses of radiography. The list supplements the bibliography published in St. John and Isenburger's "Industrial Radiography" and consists of articles published since its appearance in 1934, with a few omitted from the book. It covers the literature to April, 1940.

CONVERSION OF PETROLEUM, Production of Motor Fuels by Thermal and Catalytic Processes. By A. N. Sachanen. Reinhold Publishing Corporation, New York, N. Y., 1940. Cloth, 6 × 9 in., 413 pp., diagrams, charts, tables, $6. The most important works relating to the fundamental principles and practices of converting petroleum products into gasoline and other fuels are surveyed and discussed critically. The theories and processes of thermal and catalytic cracking, hydrogenation, polymerization, and alkylation are considered, including a large chapter on cracking equipment. The properties and treatment of cracked gasolines and other cracked products are given. The patent literature is not evaluated.

DEUTSCHE KRAFTFAHRTFORSCHUNG im Auftrag des Reichs-Verkehrsministeriums, V.D.I. Verlag, Berlin, 1939. Paper, 8 × 12 in., illus., diagrams, charts, tables. Heft 32: Bremsung des Lastzuges, by O. Dietz and L. Huber. 20 pp., 2.25 rm. Heft 33: Untersuchung der Klopfgeräusche von Ottomotoren mit elektroakustischen Messgeräten, by A. W. Schmidt and K. Generlich. 15 pp., 1.70 rm. Heft 34: Die mechanischen Verluste des schnellaufenden Dieselmotors und ihre Ermittlung mit dem Schleppversuch, by K. Ullmann. 38 pp., 4.40 rm. Heft 35: Untersuchungen über die Dauerhaltbarkeit von Fahrzeugrahmen, by A. Erker and T. Cleff. 26 pp., 2.65 rm. Heft 36: Festigkeiten und Verschleiss von Zahnrädern aus geschichteten Kunstharzpressstoffen, by H. Opitz and F. Blasberg. 17 pp., 1.90 rm. These five German automotive-research papers cover the following subjects: No. 32, braking of truck trailers; No. 33, the measurement of engine knock by electroacoustical instruments; No. 34, the mechanical losses in high-speed Diesel engines; No. 35, investigations on the durability of riveted and welded automobile frames; No. 36, strength and wear of laminated synthetic-resin gears.

DICTIONARY OF METALS AND THEIR ALLOYS, Their Composition and Characteristics. Edited by F. J. Camm. Chemical Publishing Co., New York, N. Y., 1940. Cloth, 5½ × 9 in., 245 pp., tables, $3. The principal facts concerning metals and commercial alloys, their composition, properties, and uses are presented in an alphabetical arrangement with a selection of general metallurgical terms. There are also brief special sections on hardening, case hardening and tempering, electroplating, polishing, chemical coloring, metal spraying, rustproofing, and useful tables.

ECONOMICS OF TRANSPORTATION IN AMERICA. By K. T. Healy. Ronald Press Co., New York, N. Y., 1940. Cloth, 6 × 9½ in., 575 pp., maps, charts, tables, $4. From a survey of the large amount of economic data available concerning transportation, the author presents a study of economic forces and motives, and the reasons for economic phenomena in this field. Following an historical introduction come an analysis of demands for transportation and a résumé of the construction and development of transportation facilities. The functioning of these facilities and their regulation by government action are considered in detail. A brief supplementary bibliography and a list of railroad histories are appended.

ELECTRODYNAMICS. By L. Page and N. I. Adams. D. Van Nostrand Co., Inc., New York, N. Y., 1940. Cloth, 6 × 9½ in., 506 pp., diagrams, tables, $6.50. The theoretical aspects of electrodynamics are treated in an advanced manner, covering the electromagnetic field, energy, stress, momentum, wave motion, radiation, three-dimensional and four-dimensional vector analysis, and the principle of relativity. Electrostatics and magnetostatics are generally omitted, and no attempt has been made to include quantum electrodynamics.

ELEMENTS OF ACOUSTICAL ENGINEERING. By H. F. Olson. D. Van Nostrand Co., Inc., New York, N. Y., 1940. Cloth, 6 × 9 in., 344 pp., illus., diagrams, charts, tables, $6. This book is an exposition of the fundamental principles used in modern acoustics as applied to communication, sound reproduction, and architecture, with a description of existing acoustical instruments. Particular efforts have been directed toward the development of analogies between electrical, mechanical, and acoustical systems. Measurements and testing procedures are discussed and a chapter is devoted to speech, music, and hearing.

ELEMENTS OF STRENGTH OF MATERIALS. By S. Timoshenko and G. H. MacCullough. Second edition. D. Van Nostrand Co., Inc., New York, N. Y., 1940. Cloth, 6 × 9 in., 365 pp., illus., diagrams, charts, tables, $3.25. The principal features of Timoshenko's two volumes, the "Strength of Materials," are presented in abridged form as a textbook for undergraduates. In addition to a certain amount of revision, both in the text and the large number of problems, material has been added on welded joints, photoelasticity, and moments of inertia of plane areas.

FLIGHT WITHOUT POWER. By L. B. Barringer. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1940. Cloth, 6 × 9½ in., 251 pp., illus., diagrams, charts, tables, $3.50. Gliding and soaring are comprehensively covered by various authorities. Following a brief historical summary comes an exposition of the aerodynamics of motorless flight. The design, construction, and maintenance of gliders, launching and soaring technique, meteorology, and instruments are discussed. There are chapters on flight training and soaring sites. A brief bibliography and a glossary are included.

GENERAL AERONAUTICS. By H. F. Lusk. Revised edition. Ronald Press Co., New York, N. Y., 1940. Cloth, 5½ × 8½ in., 524 pp., illus., diagrams, charts, tables, $3.75. All phases of the aviation industry are covered in this general textbook: The principles of aircraft flight; the construction and operation of airplanes; aircraft propellers; principles, construction, and operation of aircraft engines; instruments and safety appliances; avigation methods; and aeronautical meteorology. The opening chapter describes occupations in the industry, and questions and problems accompany each chapter.

INDUSTRIAL DESIGN. By H. Van Doren. McGraw-Hill Book Co., Inc., New York, N. Y., 1940. Cloth, 6 × 9½ in., 388 pp., illus., diagrams, charts, tables, $4.50. This book is presented as a practical textbook on industrial design, but is expected to be useful to the engineer, commercial artist, and businessman as well. Part 1 outlines the scope of the work, the difficulties, and something of its possibilities. Part 2 is an elementary treatise on designing in three dimensions. Technique is dealt with in part 3 covering the gathering and presentation of data and ideas, information on materials and processes. Part 4 offers problems, including possible solutions, and gives case histories of the development of three actual products.

INDUSTRIAL ELECTROCHEMISTRY. (Chemical Engineering Series). By C. L. Mantell. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y., 1940. Cloth, 6 × 9½ in., 656 pp., illus., diagrams, charts, tables, $5.50. A considerable range of subject matter is covered in this comprehensive textbook: The theoretical and technical sides of electrochemistry; the aqueous and fused-electrolyte industries; electrothermics; the electrochemistry of gases; and such engineering aspects as power generation and the materials used in the construction of electrochemical equipment. New material has been added in this edition and some rearrangement of topics has been made.

IRON AND STEEL TO-DAY. (The Pageant of Progress.) By J. Dearden. Oxford University Press, New York, N. Y., and Toronto, Canada, 1939. Cloth, 5½ × 9 in., 190 pp., illus., diagrams, charts, tables, $1.75. A simple, interesting account of the various processes used in the production of iron and steel products, with explanations of the reactions and reasons involved. The blast furnace, iron foundry, Bessemer converter, open-hearth, and electric furnace are described. Casting, working, testing, heat-treatment, and various grades of steel are explained. The book is one of a series on technical subjects by recognized English authorities.

MACHINE DESIGN DRAWING ROOM PROBLEMS. By C. D. Albert. Third edition. John Wiley & Sons, Inc., New York, N. Y., Chapman & Hall, London, England, 1940. Cloth, 6 × 9½ in., 441 pp., diagrams, charts, tables, $3.50. The basic idea of this text is that complete, comprehensive problems of machine design are preferable to those that deal with unrelated details or groups of details. The course here presented offers thirteen chapters of problems of a comprehensive nature. In addition are several chapters of reference information on stresses, gears, and tolerances.

MACHINE SHOP TRAINING COURSE, 2 volumes. By F. D. Jones. Industrial Press, New York, N. Y., 1940. Cloth, 6 × 9½ in., illus., diagrams, charts, tables; Vol. 1, 474 pp.; Vol. 2, 552 pp; $4 each volume if purchased separately; $6 for Vols. 1 and 2 together. This treatise on machine-shop practice is especially designed for use as a text in manufacturing plants and vocational schools. It covers the fundamental principles, methods of adjusting and using different types of machine tools, measuring instruments and gages, screw-thread cutting, thread grinding, gear cutting, and precision toolmaking methods. The chapter subheadings are in the form of questions which are answered in a practical manner with typical examples. There is a large glossary with full definitions.

METHODS FOR THE DETECTION OF TOXIC GASES IN INDUSTRY, Great Britain Department of Scientific and Industrial Research. Leaflet No. 7. CARBON MONOXIDE. His Majesty's Stationery Office, London, England, 1939. Paper, 6 × 10 in., 9 pp., illus., diagrams, tables, 1s 6d (obtainable from British Library of Information, 50 Rockefeller Plaza, New York, $0.45). Tested and standardized methods for the detection of dangerous gases in low concentration are presented in this series of leaflets. In the present one, the poisonous effects of carbon monoxide are given, in addition to a detailed description of its detection by means of the reduction of palladium chloride to metallic palladium.

MODERN STEELS, Manufacture, Inspection, Treatment, and Uses. Edited by E. E. Thum, American Society for Metals, Cleveland, Ohio, 1939. Cloth, 6 × 9 in., 374 pp., illus., diagrams, tables, $3.50. This volume contains the substance of a series of thirteen lectures delivered before the Pittsburgh chapter of the American Society for Metals. The topics discussed include the raw materials, the production of pig iron, the steel-making process, steel pouring, hot rolling and forging, inspection and testing, metallography, heat-treatment, and alloy, stainless, and tool steels. The lectures are designed as practical introductions to these subjects. There are exercises and suggestions for further reading.

OUTLINE OF INDUSTRIAL RELATIONS POLICIES IN DEFENSE INDUSTRIES. Princeton University, Industrial Relations Section, Princeton, N. J., June, 1940. Paper, 7 × 10 in., 47 pp., $0.75. Brief discussion and reported experiences are presented on the following topics: Expansion of management organization; recruitment of production workers; training of skilled and semiskilled workers; wages and hours of work; employee-management cooperation in accelerated production. There is a selected bibliography.

OUTLINE OF METALLURGICAL PRACTICE. By C. R. Hayward. Second edition. D. Van Nostrand Co., Inc., New York, N. Y., 1940. Cloth, 6 × 9 in., 690 pp., illus., diagrams, charts, tables, $7.50. Fundamental information concerning metallurgical processes is given for each metal in turn. Concentration, roasting, smelting, and refining are described, together with special processes for certain metals, and brief information is included on occurrence, mining methods, and physical properties. Nonferrous alloys are discussed briefly. Supplementary reading lists accompany most of the chapters. The book has been revised to keep in line with present-day practice.

PLASTICS IN ENGINEERING. (Machine-Design Series.) By J. Delmonte. Penton Publishing Co., Cleveland, Ohio, 1940. Cloth, 6 × 9½ in., 616 pp., illus., diagrams, charts, tables, $7.50. This work is intended for the machine designer and manufacturer, rather than the chemist, and it aims to present the data needed by designers in convenient form for reference. The opening chapters review the various types of plastics, methods of compounding, and physical and chemical properties. Succeeding chapters discuss methods of molding, uses for bearings, gears, and other machine parts, engineering applications of plastics, fabrication and finishing of plastic parts, and common failures. A chapter is devoted to synthetic rubbers.

POUR LE MONTEUR-MÉCANICIEN. By E. Ambroise. Dunod, Paris, 1940. Paper, 4½ × 7 in., 137 pp., diagrams, tables, 18 fr. Practical information is given concerning the erection, repairing, regulation, and maintenance of various kinds of machinery. Sample indicator diagrams and other useful data are included.

PRACTICAL PETROLEUM ENGINEERS' HANDBOOK. By J. Zaba and W. T. Doherty. Second edition, revised and enlarged. Gulf Publishing Co., Houston, Texas, 1939. Leather, 5½ × 9 in., 492 pp., illus., diagrams, charts, tables, $5. This work is intended to provide a collection of information constantly wanted by those in the petroleum industry, in convenient form for quick reference. So far as possible, the data are presented in charts, tables, and formulas. Only such textual material is included as is necessary to explain theoretical questions and practical operations. The contents include data upon general engineering matters, steam production, power transmission, drilling, oil production, and pipe-line transportation.

PRESENTING FLEX-ANAL CHARTS, A NEW AND MODERN TREATISE FOR DESIGN OF PIPING FOR FLEXIBILITY. By E. A. Wert and S. Smith. Blaw-Knox Company, Power Piping Division, Pittsburgh, Pa., 1940. Fabrikoid, 8½ × 11½ in., 80 pp., illus., diagrams, charts, tables; free to those interested in piping-design problems; $3 to general public. To facilitate the rapid designing of piping systems, methods and procedures are given for flexibility analyses and for determining the magnitudes of forces, moments, stresses, and movements. These procedures are based on a large group of charts which relate only to the use of wrought iron and certain steels, although the formulas are applicable to other materials.

PROCEDURE HANDBOOK OF ARC WELDING DESIGN AND PRACTICE. Sixth edition. Lincoln Electric Co., Cleveland, Ohio, 1940. Cloth, 6 × 9 in., 1117 pp., illus., diagrams, charts, tables, $1.50 in United States; $2 elsewhere. Like preceding editions, this is intended as a reference book containing the basic information on arc welding. The various forms of arc welding are fully described, the welding of various metals is explained, and much space is devoted to designing of machinery and structures for arc-welded construction. This edition has been carefully brought up to date and considerably expanded.

QUALITY OF COKE. By R. A. Mott and R. V. Wheeler, with a foreword by W. J. Brooke. Chapman and Hall, London, England, 1939. Cloth, 6 × 10 in., 464 pp., illus., diagrams, charts, tables, 36s. The reports of the Midland Coke Research Committee present the results of investigations on the constitution and properties of coking coals, the fundamental factors of coke formation, the properties of coke, test methods, and large-scale tests on the use of selected varieties of coke in blast furnaces. The present report deals with work completed by the end of 1937. A considerable number of tabular and graphical data are included.

ROYAL TECHNICAL COLLEGE JOURNAL, Glasgow, Scotland, Vol. 4, Part 4, January, 1940, pp. 607–796. Robert Anderson & Sons, Ltd., Glasgow, C 1, Scotland. Paper, 7 × 10 in., illus., diagrams, charts, tables, 10s 6d. This publication constitutes a record of some of the research work carried out in the college by the staff and senior students. The topics of the fifteen papers include a wide range of investigations in the fields of physical chemistry, metallurgy, mechanics, aerodynamics, electrical measurements, mining, etc.

S.A.E. HANDBOOK, 1940 edition. Society of Automotive Engineers, 29 West 39th St., New York, N. Y. Cloth, 6 × 9 in., 834 pp., illus., diagrams, charts, tables, $5. All the current standards and recommended practices of the Society of Automotive Engineers concerning automobile and aircraft materials and parts, tests and codes, production equipment, nomenclature, and definitions are contained in this annually revised handbook. Fifty-five changes (new and revised standards, corrections, and cancellations) from the 1939 edition are noted.

STEAM POWER STATIONS. By G. A. Gaffert. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y., 1940. Cloth, 6 × 9 in., 592 pp., illus., diagrams, charts, maps, tables, $4.50. This comprehensive and interesting volume on steam power-station work falls roughly into two sections. Chapters 1–17 deal with the construction and performance characteristics of the mechanical equipment, including fuels and feedwater. The succeeding chapters, 18–24, cover plant economics and the integration of the machinery, with considerable discussion of steam and binary-vapor cycles. Problems and short bibliographies are included with the separate chapters.

THEORETICAL PHYSICS. Vol. 3, Relativity and Quantum Dynamics, Einstein-Planck. By W. Wilson. E. P. Dutton & Co., New York, N. Y., 1939. Cloth, 5½ × 9 in., 276 pp., diagrams, charts, tables, $5.75. The final volume of this text covers relativity and quantum dynamics in such a way, as in the preceding volumes, as to present physical theory as a coherent logical unity. The discussion of relativity passes from Einstein's special theory to the general theory. The development of the quantum theory, starting with Planck, takes in wave mechanics, matrix mechanics, and electron theory. The latter part of the volume discusses the analogy between geometrical optics and Hamiltonian dynamics, and its application to quantum dynamics.

UNTERSCHUNGEN AN EINER KREISELPUMPE MIT LABILER KENNLINIE. By R. Dziallas. V.D.I. Verlag, Berlin, Germany, 1940. Paper, 6 × 8 in., 58 pp., illus., diagrams, charts, tables, 6.50 rm. A report of investigations of a centrifugal pump with unstable characteristics. The test setup and measuring equipment are described, the theoretical treatment is discussed, and the test results are presented.

WERKSTOFFHANDBUCH NICHTEISENMETALLE, Abschnitte D bis F. Edited by Deutsche Gesellschaft für Metallkunde im Verein deutscher Ingenieure. V.D.I. Verlag, Berlin, Germany, 1940. Paper, 6 × 8½ in., 146 pp., illus., diagrams, charts, tables, 12 rm. The revision of the V.D.I. handbook of nonferrous metals continues with the appearance of this loose-leaf publication containing the sections on copper, brass, and bronze. Concise information is given on manufacture, mechanical, physical, and chemical properties, working, and uses, in articles by German authorities.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

61st Annual Meeting of A.S.M.E., New York City, Dec. 2–6, 1940

Committee Lists Ten Reasons Why Every A.S.M.E. Member Should Attend Affair at the Hotel Astor

KEYNOTING better living and greater industrial progress through engineering, the Sixty-First Annual Meeting of The American Society of Mechanical Engineers to be held in New York City, Dec. 2–6, 1940, with headquarters at the Hotel Astor instead of the Engineering Societies Building, promises to be the greatest and best Annual Meeting ever held by the Society. Under the direction of the Committee on Meetings and Program, plans are being made for 45 technical sessions, several score committee meetings, annual business meeting, presenting of A.S.M.E. honors and awards, Annual Dinner, Student Day, and numerous luncheons and special dinners.

Whether you are a junior or a fellow member, whether you live in New York City or in a town thousands of miles away, the Committee feels that you should attend if possible:

1 To obtain latest technical information;

2 To establish and maintain personal friendships;

3 To take part in the democratic functioning of the Society by being present at the Annual Business Meeting;

4 To sit with committees organized to formulate test codes, safety rules, research projects, and Society policy;

5 To honor outstanding engineers by your presence at Honors Night;

6 To hear inspirational addresses by the President of the A.S.M.E. and others;

7 To visit and inspect new plants and projects in the New York Metropolitan area;

8 To see one of the outstanding exhibits of technical photography;

9 To examine and use the facilities of the greatest engineering library in the world; and

10 To see the exhibits at the Power Show and to talk with the manufacturers of appliances, devices, equipment, and machinery.

Fairchild Aerial Surveys, Inc.

AIRPLANE VIEW OF NEW YORK CITY LOOKING NORTH

[(1) The Engineering Societies Building, headquarters of A.S.M.E. (2) Hotel Astor, headquarters for 1940 A.S.M.E. Annual Meeting. (3) Pennsylvania Railroad Station. (4) Grand Central Terminal. (5) Grand Central Palace where Power Show will be held.]

Official Notice

A.S.M.E. Business Meeting

THE Annual Business Meeting of the members of The American Society of Mechanical Engineers will be held Monday afternoon, December 2, at 2:00 p.m. at the Hotel Astor, New York City, as a part of the Annual Meeting of the Society.

The Annual Report of the Council and other Committee reports will be presented for the action of the members. There will be an opportunity also for members desiring to do so to bring any other business before this meeting.

(*Signed*) C. E. DAVIES
Secretary

Latest Technical Information

Engineering is a progressive science, as is evidenced by the hundred or so papers scheduled for presentation during the 1940 Annual Meeting. Covering the many phases of mechanical engineering, the technical sessions will give an opportunity for an engineer to keep up with the progress in his field through such papers as the following: *Aeronautics*, "The Work of the Civil Aeronautics Board;" *applied mechanics*, "High-Speed Tensile Tests at Elevated Temperatures," and "Magnetic Testing to Detect Cracks in Nonferrous Metals;" *education and training for the industries*, several papers by outstanding engineers and industrialists; *fuels*, "New Data on Coal Ash and Slag in Boiler Furnaces," and "New Design of Wood-Burning Stove;" *heat transfer*, several papers on theory and fundamental research; *hydraulics*, descriptions of various new hydroelectric projects and Kaplan turbines; *machine-shop practice*, "Experience With Manual on Cutting of Metals," "The Best Method of Milling," and "The Modern Elevator;" *management*, papers on work standardization, marketing, mathematical statistics, and power; *materials handling*, "Modern Cargo-Handling Appliances."

Also *metals engineering*, papers on seamless-tube manufacture and extrusion; *petroleum*, papers on latest engineering developments; *power*, "A New Steam Engine and Boiler," and "Condenser Tubes and Their Corrosion;" *process industries*, papers on rubber and plastics, instruments, dust collectors, and safety; *railroads*, papers on the new Hill car and on steam

Courtesy N. Y. Convention Bureau

NEW YORK SKY LINE AT NIGHT

locomotives; *textile*, papers on new textile products; *research*, papers on cutting of metals, boiler-feedwater studies, effect of temperature on metals, fluid meters, lubrication, and mechanical springs. A complete and detailed program will be published in the November issue of MECHANICAL ENGINEERING.

Friendships

If you have ever attended an A.S.M.E. Annual Meeting, you will recall with pleasure your meeting long-forgotten acquaintances and making new ones. This year, a greater number of out-of-town members are coming to New York for the big affair. The "bull-session" periods, before and after technical sessions, dinners, luncheons, and other functions will enable old friends to get together to swap experiences and stories. A member, who is now one of the "Old Guard," claims that he gets more value out of the social functions than out of the technical sessions. Several juniors in good positions owe this to the fact that they first met their present employers at an Annual Meeting.

If you are dissatisfied with your present job, or are without one, there will be present at the Hotel Astor every day of the meeting a qualified representative of the Engineering Societies Personnel Service to discuss your particular problem. Where possible, this personnel man will try to arrange personal interviews between qualified applicants and prospective employers.

Annual Business Meeting

Even though you, as a member, have helped to select a Local Sections delegate to come to the Annual Meeting and to present your problems to Council, it is possible for you to assist the democratic functioning of your Society by attending the Annual Business Meeting at which the Council, financial, and committee reports will be presented for your approval. If you have any comments or suggestions, they will be welcomed for consideration by Council.

Meeting of Committees

In an organization of 15,000 members organized to aid the profession, its members, and the general public, much of the work of formulating policies, preparing technical recommendations, conducting research projects, standardizing good practices, and numerous other tasks must be carried on by committees whose members serve without pay but obtain much experience and satisfaction. An old axiom applicable to every member is "that you get as much out of the Society as you put into it."

Outstanding Engineers

Records of scores of candidates are now being examined by the Board of Honors and Awards in order to select the outstanding engineers of 1940 for such awards as the A.S.M.E. Medal, Melville Medal, Holley Medal, Worcester Reed Warner Medal, the Pi Tau Sigma Award, and the Junior Award. Engineering student papers are also being read in order to select the winners of the Charles T. Main Award of $150 and the two Student Awards of $25 each. It is expected that the awards and medals will be presented at a suitable occasion during the Annual Meeting.

If you have ever heard a talk by Warren H. McBryde, President of the A.S.M.E., you will want to be present to hear his presidential address. In order to acquaint mechanical engineers with developments in other scientific fields, the Committee on Meetings and Program is making arrangements to have technical as well as general papers presented by experts in those fields.

Inspection Trips

The last Annual Meeting held in New York City took place in 1938. Since then, many new projects of interest to mechanical engineers have been constructed. Some of these to which inspection trips may be made include the Sixth Avenue Subway (opening December 25), the East River-Midtown Tunnel (opening in December), S.S. *America* (in port December 5 and 6), the new Belt Parkway with its sodium lights, La Guardia Airport, the new 1475-psi, 925-F, 65,000-kw steam-power generators at Waterside, the color-television equipment of the Columbia Broadcasting System, the Parkchester private-housing development (the largest in the world), and numerous new industrial plants.

Photographic Exhibit

The Fifth Annual Photographic Exhibit of the A.S.M.E. will feature almost 200 prints by members of the Society and their friends. Although the showing is not restricted as to sub-

United States Lines

AMERICA'S NEW QUEEN OF THE SEAS AGAINST NEW YORK SKY LINE

(The S.S. *America*, new flagship of the United States Lines, is the largest liner ever built in the United States. The ship cost $17,500,000 and carries 1202 passengers. It is hoped that an inspection trip may be made sometime during the week of the Annual Meeting.)

ject, the majority of the pictures will be technical in nature. Whether you have made an entry or not, the exhibit will interest you. Arrangements are now being made for a special demonstration at this exhibit which will show how an aircraft manufacturer has applied photography in making tracings and templates of wood, metal, and plastics.

Library Exhibit

Throughout the Annual Meeting there will be a special exhibit in the Engineering Societies Library, 29 West 39th Street, covering books and periodicals mentioned in the bibliographies of several of the papers to be presented at the technical sessions. There will also be shown engineering publications issued in the early days of printing, together with some of those of recent times which may be of interest to mechanical engineers.

Visitors to the library may examine any of its 141,000 volumes, 7000 maps, and 4000 special technical bibliographies, the periodical index of more than 250,000 references to important engineering articles, samples of photostatic and microfilm work, and early engineering drawings. The director of the library, Dr. Harrison W. Craver, will be glad to meet members of the A.S.M.E. and to explain to them the library's new loan policy.

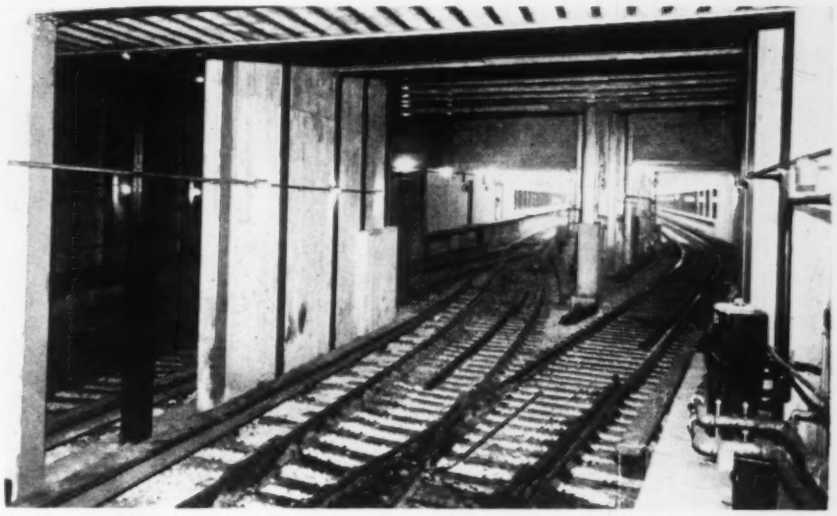
Power Show

During the week of December 2, 1940, the 14th National Exposition of Power and Mechanical Engineering, under the management of the International Exposition Co., will be on view at Grand Central Palace. To date more than 270 concerns have contracted for space to display their wares. As usual, the show will provide an opportunity to inspect the latest developments in mechanical and power equipment.

Fifth Annual A.S.M.E. Photographic Exhibit, New York, Dec., 1940

MEMBERS of the Society and their friends are invited to submit technical and nontechnical photographs for showing at the Fifth Annual A.S.M.E. Photographic Exhibit to be held during the 1940 Annual Meeting of the A.S.M.E. in New York City, Dec. 2–6, 1940. Prints mounted on 16 × 20-in. light-colored cards should be sent, on or before Nov. 27, 1940, to the A.S.M.E Photo. Exhibit Committee, 29 West 39th Street, New York, N. Y., together with an entry fee of 50 cents to cover return postage, insurance, and wrapping.

A board of judges, consisting of nationally famous photographers, will select outstanding prints for cash prizes amounting to $15. The best technical photographs, based on subject and reproduction possibilities, will be used in Mechanical Engineering. Additional information may be obtained from the Committee.



A GLIMPSE OF THE NEW SIXTH AVENUE SUBWAY IN NEW YORK CITY TO BE OPENED IN DECEMBER, 1940

Solid Fuels in the Steel Industry, Subject of Joint A.S.M.E.-A.I.M.E. Coal Meeting

To Be Held in Birmingham, Ala., November 7–9

SOLID fuels in the steel industry will be the subject of the fourth annual joint meeting of the Fuels Division, The American Society of Mechanical Engineers, and the Coal Division, American Institute of Mining and Metallurgical Engineers, at the Hotel Tutwiler, Birmingham, Ala., Nov. 7–9. The technical program for the meeting is now being prepared and will be published in the next issue of Mechanical Engineering.

Utilization of coals and coking coals, underfeed stokers, design and operation of preparation plants, flow processes in underfeed stokers, and coal drying will be some of the topics to be covered at the four or more technical sessions. Inspection trips arranged for the meeting include visits to the Stockham Pipe & Fittings Co. plant where solid fuel is fired directly for annealing-furnace purposes; the American Cast Iron Pipe Co., where by-product gas is used for drying and heating; the Republic Steel Corporation's new sintering plant; the Woodward Iron Company's air-conditioned blast-furnace operations; the Alpha Portland Cement Company's pulverized-coal cement kilns; the Sloss-Sheffield Steel & Iron Co., where pulverized coal is used in the boiler plant; and the coal and iron mines of the Tennessee Coal, Iron, and Railroad Co.

Real Southern hospitality will be in evidence all throughout the three-day meeting, but especially at the luncheon and the banquet. Already the Governor of Alabama, the honorable Frank M. Dixon, has consented to be one of the speakers at the banquet. Football fans among the meeting participants will have an opportunity to attend the game at Birmingham between the University of Alabama and Tulane University on Saturday afternoon, November 9.

Geo. A. Orrok Represents A.S.M.E. at Conference

REPRESENTING the A.S.M.E. at a Conference on Science, Philosophy, and Religion in Their Relation to the Democratic Way of Life, held in New York City, Sept. 9–11, 1940, was Geo. A. Orrok, honorary member of the Society.

Col. E. E. Aldrin Appointed Secretary of Aero Division

ONE of the founders of the A.S.M.E. Aeronautic Division and its first secretary, Col. Edwin E. Aldrin, consulting aeronautical engineer, has been appointed to fill the secretaryship of the Division which became vacant with the resignation of Jerome Lederer upon his appointment as head of the Air Safety Bureau of the Civil Aeronautics Board.

Consistency Classification for Lubricating Greases

THE National Lubricating Grease Institute at its annual convention in Chicago in 1939 adopted a classification for lubricating greases which has now been copyrighted. This classification gives the grade numbers and the A.S.T.M. worked penetration for each grade. While this classification is in no way a standard or specification of quality, it establishes the body or consistency of the grease and assures the manufacturers and consumers of lubricating greases of securing uniform bodies or consistencies while using this classification.

A.S.M.E. Discusses Shell Manufacture at Pittsburgh Meeting, Sept. 11

Army Officers and Manufacturers Contribute to Program

MORE than 250 engineers and industrial executives attended a highly significant meeting devoted to the manufacture of shell held under the auspices of The American Society of Mechanical Engineers at the William Penn Hotel in Pittsburgh, Pa., on Sept. 11, 1940. The Metals Engineering and Machine Shop Practice Divisions, with the cooperation of the Pittsburgh Section staged a program of three sessions which drew a crowd that taxed the meeting room and kept unflagging interest from the drop of the gavel at 9:30 a.m. until the final adjournment at 10:00 p.m. And after the formal sessions adjourned, small knots of serious discussers continued into the night.

The meeting was a practical realization of the desire of the A.S.M.E. to bring definite help to the War Department and particularly the Ordnance Department by providing an opportunity for the interchange of experience and information on the forging and machining of shell. The meeting was particularly well timed, following as it did closely on the signing of the bill which appropriated five billion dollars for the national defense, thus initiating the ammunition program and giving hard realization to the long-laid plans of the Ordnance Department.

James L. Walsh, chairman of the A.S.M.E. Committee on National Defense, called the meeting to order and after directing the attention of the audience to the seriousness of the occasion, introduced Col. Burton O. Lewis, U.S.A., assistant chief of the Industrial Service of the Ordnance Department, who presented the address of Maj.-Gen. Charles M. Wesson, Chief of Ordnance, U. S. Army. General Wesson's message was in part as follows:

General Wesson's Message on the Shell Problem

The Ordnance Department is deeply grateful to The American Society of Mechanical Engineers for arranging this gathering of engineers and manufacturers interested in the forging and machining of shell for the Army.

The Congress has provided funds for an army on a peacetime scale never before contemplated. Complete equipment for 1,200,000 men, the critical needs for an additional 800,000, and 18,000 aircraft with armament and bombs are to be provided. As compared to the last war, per unit of man power, more antiaircraft weapons, more tanks, more mortars, bigger guns, and more aircraft armament are needed. Again compared to 1917, this will require a greater industrial effort, and none of these items are produced in peacetime by the industries of the nation. With but one or two exceptions, the designs have been completed and standardized, and the ordnance arsenals have produced small quantities of the product. On many of the items industry is now busy, but the great quantity of ordnance that must be produced is only now authorized by the appropriation bill the President signed Monday.

District Offices Set Up by Ordnance Department

One of the most important lessons learned in the last war was the necessity for decentralizing the task of supervising the procurement, production, and inspection of the material making up the ordnance program. The Ordnance Department has, therefore, perfected the system of district offices, thirteen of which have been carrying on in peacetime, training reserve officers, surveying the manufacturing plants in their neighborhoods, preparing estimates of the volume of ordnance production that could be handled, administering educational orders and production studies, and, for the last two years, handling the inspection of ordnance produced in the district areas, contracts for which had been let through the various ordnance arsenals. Some six weeks ago, in anticipation of the passage of the latest appropriation bill, the various items on the ammunition program were allocated to the district offices which have been at work on the preliminaries so that at the signing of the bill contracts can be negotiated and production started. The advantages of doing business with conveniently located government representatives in whom you have confidence are so obvious that argument is hardly needed. We are, therefore, looking forward with keen anticipation to the prompt consummation of contracts and the rapid entrance into production.

The Ammunition Program

The ammunition program provides for the manufacture of the metal components in separate plants throughout the country and the assembly of the components with the explosives in conveniently located ordnance loading plants, which will be constructed for that purpose. The sizes in which we are principally interested at this meeting include the 60-mm and 81-mm mortar shell, the 3-in. and 90-mm antiaircraft shell, and the 75-mm, 105-mm, and 155-mm shell, both high-explosive and chemical. Inasmuch as one of the principal weapons is to be the 105-mm howitzer, the largest quantity of any one item may be the 105-mm shell. The 3-in. antiaircraft may be made from tubing and an alternative method of making 60-mm mortar shell by casting has been approved. Roughly two thirds of the shell will be made from forgings. All of the shell will require machining. The schedule calls for the forgings to start flowing to the machine shops in quantity by January, 1941, and the finished machined shell to start in February, 1941, and be completed in February, 1942. The total quantity of shell to be produced runs into many millions. In addition to shell, the ammunition program includes cartridge cases for fixed ammunition, boosters, fuses, explosives, and a large quantity of bombs ranging in size from 100 lb to 2000 lb. Large quantities of 37-mm and 20-mm ammunition will also be required, but these smaller sizes are somewhat outside the scope of this meeting.

Choke Points in Shell Production

It is obvious that one of the choke points in shell production will be the provision of the necessary forging presses and machine tools to do the job. In placing contracts, therefore, it is of great importance that plants be used which already have a large part of the machinery installed or available. Rapid improvisation of the necessary machinery is a possibility and the organization with Yankee ingenuity to turn the existing equipment to the task of forging and machining shell will have widespread recognition and the wholehearted appreciation of the Ordnance Department.

The defense needs of the Army and the Navy will require a tremendous quantity of noncommercial items which are not traded in over any counter. To provide them, much new equipment will be needed, probably to an extent greater than the ability of the equipment industries to provide. To meet the needs every bit of productive capacity, obsolete though it may be, must be studied and used if at all possible. As the emergency needs are met and equipment becomes available, it will be possible to improve the efficiency of the operations by the addition of more modern machinery. At the moment, however, too much emphasis cannot be placed on the importance of doing what can be done with the machinery at hand or immediately available.

A second choke point promises to be the provision of gages. Here again improvisation of emergency methods of gaging and gage manufacture will be of great assistance in getting the program under way in the shortest possible time.

The ammunition program, more than any other part of the ordnance program, will be spread widely over the industry of the nation. In order that the final product in the form of complete rounds will be available to the using services at the times they will be needed, tremendous efforts must be exerted at the start of the program to overcome difficulties inherent in the manufacture of any new product and which may be particularly critical when the new product has no commercial counterpart. Every ingenuity and skill of improvisation must be brought into play to conquer the important time element. Your wholehearted cooperation to that end is sincerely requested.

Manufacturers Discuss Forging Methods

At the close of Colonel Lewis' forceful presentation, Mr. Walsh introduced Prof. W. Trinks of Carnegie Institute of Technology and chairman of the A.S.M.E. Metals Engineering Division who presided during the presentation of the papers on forging and guided the discussion skillfully through the controversial maze of conflicting experience. The first paper was presented by Frederick G. Schranz, general manager of the Baldwin-Southwark Division of the Baldwin Locomotive Works, who discussed several hydraulic

At the A.S.M.E. Meeting on Manufacture of Shell, Pittsburgh, Pa., September 11, 1940

[(1) Col. B. O. Lewis, office of Chief of Ordnance, and James L. Walsh, Chairman, A.S.M.E. Committee on National Defense. (2) Lt-Col. A. B. Johnson and Major J. L. Holman of Ordnance Department and Sol Einstein of Cincinnati Milling Machine Co. (3) James R. Longwell, chief engineer, Carboloy Co., and E. P. Blanchard, sales manager, Bullard Co. (4) J. H. Friedman, vice-president, National Machinery Co., P. H. Miller, and J. R. Longwell, Carboloy Co. (5) J. H. Friedman. (6) E. C. Batchelar, Pittsburgh manager, Motch & Merryweather Co., and W. D. Creider, Sheffield Gage Co. (7) J. H. Friedman. (8) Col. E. C. Bomari, Lt-Col. A. B. Johnson, and J. L. Walsh. (9) F. G. Schranz, general manager, Baldwin-Southwark Division, Baldwin Locomotive Co. (10) E. P. Blanchard, Bullard Co., and Carl Bintz of Wickes Brothers. (11) C. A. Birkbak, Ex-Cell-O Corp., H. R. Wickes, president, Wickes Brothers, Carl Bintz, C. E. Davies, Secretary A.S.M.E., Lt-Col. A. B. Johnson. (12) J. L. Walsh and Lt-Col. M. W. Kresge.]

A.S.M.E. Calendar

of Coming Meetings

November 7–9, 1940
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions
Hotel Tutwiler
Birmingham, Ala.

December 2–6, 1940
Annual Meeting
Hotel Astor
New York, N. Y.

April 1–3, 1941
Spring Meeting
Atlanta, Ga.

June 16–20, 1941
Semi-Annual Meeting
Kansas City, Mo.

October 12–15, 1941
Fall Meeting
Louisville, Ky.

(*For coming meetings of other organizations see page 30 of the advertising section of this issue*)

and mechanical methods of forging shell. He was followed by J. H. Friedman, vice-president of the National Machinery Company, who described forging machine methods of making shell. The questions and comments dealt with the relative merits of the various methods and the gamut of problems from the billet preparation to the final inspection. Motion pictures and samples of the products made by the various methods dramatized the discussion.

The meeting adjourned at 12:30 for luncheon at which R. S. Marthens of Pittsburgh presided. Mr. Walsh made a few remarks comparing the status of the program today with the situation as it was in 1917 and read a telegram of greeting from President McBryde of the Society.

Machining of Shell Topic at Afternoon Session

At 2:30 p.m. the meeting reassembled under the tactful chairmanship of Lieut-Col. A. B. Johnson of the office of the Assistant Secretary of War. Lieut-Col. E. C. Bomar of Frankford Arsenal introduced a motion-picture film showing the shell-machining methods in use at Frankford Arsenal. Captain Alford explained the various steps in the process and answered the many questions that arose at the close of the presentation. The second paper was given by E. P. Blanchard, of the Bullard Company, who spoke from his wide experience and his observations in Europe. L. E. Melhope, of the Cincinnati Milling Machine Company, then presented some production data on the grinding of various forms of shell.

The discussion brought out the general differences between the methods of machining shell, particularly the comparisons between the single-purpose machines and the multi- or special-purpose methods of production. Costs, cutting materials, and inspection requirements were treated and representatives of the various types of tools were given an opportunity to defend their methods. The meeting adjourned at five-thirty and the audience went to dinner in small groups to carry on the discussion.

In the evening Erik Oberg, member of the executive committee of the Machine Shop Practice Division and editor of *Machinery*, called the round-table conference to order and introduced the opening discussion on "Shall Shell Cavities Be Forged?" by Lucien I. Yeomans of Chicago. Comment and question of the opening discussion and of the many questions on forging and machining that were missed during the day ensued and the meeting continued until 10:00 p.m.

Ordnance Department Represented

The Ordnance Department was represented, in addition to those already mentioned, by Lieut-Col. Miles W. Kresge, Lieut-Col. A. B. Domonoske, and Major J. L. Holman. Colonel Kresge responded fully and frankly to the questions about specifications and inspection requirements.

The details of the program were cared for by Prof. A. F. Macconachie, of the University of Virginia, who served as a special representative of the Society for that purpose.

The importance of the problem and the success of the meeting supported the decision of the Society to offer further opportunity to continue the discussion at later meetings and pointed the way to a meeting on the subject to be held at Cincinnati on October 16 and 17, 1940.

The Pittsburgh Section of the Society arranged for the details of registration and the luncheon and Messrs. McConnell, Stone, and Treschow, of the Executive Committee of the Section, were on hand to greet the visitors and serve their needs.

Second Shell Meeting

Hotel Gibson, Cincinnati, Ohio, Oct. 16–17

Under auspices of Machine Shop Practice Division, Metals Engineering Division, and Cincinnati Section of the A.S.M.E. there will be held a second meeting to discuss shell manufacture at Pittsburgh, Pa., October 16 and 17. The Iron and Steel Division of the American Institute of Mining and Metallurgical Engineers and the Army Ordnance Association will cooperate in the meeting. The preliminary program for this meeting follows:

Wednesday, Oct. 16

Morning Technical Session

Metallurgy of Shell Steel
Heating of Billets

Afternoon Technical Session

Shell Forging
(*a*) Flow of metal during shell forging
(*b*) Analysis of shell-forging equipment

Evening Dinner. Address

Thursday, Oct. 17

Morning Technical Session

Shell Machining
(*a*) Analysis of shell-machining equipment
(*b*) Single-purpose vs. special multiple-type machinery
(*c*) When and where to obtain machine tools

Classification of Surface Finish

Noon

Luncheon and Group Discussion

Afternoon Technical Session

Fuse Manufacture

United States Lines

BOILER ROOM OF THE NEW S.S. "AMERICA"

(It is hoped that an inspection trip of this ship may be arranged for those in attendance at the A.S.M.E. Annual Meeting in December.)

1940 Local Sections Group Conferences

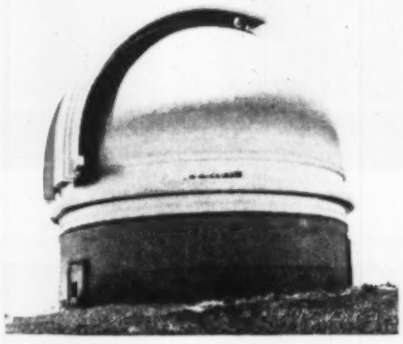
Group	City	Place	Date	In charge of	Presiding officer
I	New Haven	Graduates Club	Nov. 2	W. F. Thompson	G. R. Truedsson, Hartford
II	New York	A.S.M.E. Headquarters	Oct. 17	A. R. Mumford	O. B. Schier, 2nd, Metropolitan
III	Bethlehem	Lehigh University	Oct. 19–20	R. H. Porter	A. R. Acheson, Syracuse
IV	Birmingham	Tutwiler Hotel	Oct. 25–26	H. S. Kent	A. D. Asbury, Greenville
V	Cleveland	Statler Hotel	Oct. 19–20	J. P. Dearasaugh	H. M. Gano, Dayton
VI	Milwaukee	Hotel Pfister	Oct. 26–27	T. Eserkaln	F. H. Dorner, Milwaukee
VII	Portland	Multnomah Hotel	Nov. 2–3	A. D. Hughes	W. D. Turpin, Utah
VIII	Dallas	Baker Hotel	Oct. 19–20	R. M. Matson	.....

A.S.M.E. Local Sections Continue Meetings and Inspection Trips Throughout Summer

San Francisco Section Greets H. N. Davis at Luncheon and Los Angeles Section Holds Three-Day Inspection Trip

AT THE regular monthly luncheon of the San Francisco Section, held on Thursday, Aug. 8, the guest of honor was Harvey N. Davis, past-president of the A.S.M.E., who was introduced by President Warren H. McBryde. Most of the members, who were present and who had planned to attend the launching ceremonies of the S.S. *American Manufacturer*, failed to see the event, becoming so engrossed in the conversation.

Los Angeles Section scheduled an inspection trip during August through the television laboratories of the Gilfillan Radio Company. The response was so great that it was necessary to extend the program over three evenings since the laboratories could accommodate only 100 at one time. Attendance was as follows: August 7, 100; August 8, 84; and August 9, 43. C. Federick Wilcott, chief engineer of the Company, opened each evening's program with a talk on the fundamentals of television. Following this, a demonstration of an actual television broadcast was given. Interesting features about television were then shown by means of working exhibits and experimental setups in the laboratories. The program was closed with a general discussion on the present and future possibilities of television.



AN INSPECTION TRIP WAS MADE BY 225 LOS ANGELES SECTION MEMBERS AND FRIENDS ON JUNE 15 TO THE MT. PALOMAR OBSERVATORY

(The black spots seen on the rim of the dome are some of the A.S.M.E. members who, through the efforts of Prof. W. H. Clapp and the courtesy of Mark Serruier, chief engineer of the Observatory, were taken on a tour of the entire installation from top to bottom, including the Diesel-operated power plant and the "kitchen" where an excellent luncheon was served.)

1941 A.S.M.E. Mechanical Catalog and Directory Out

New Volume Contains More Than 500 Pages of Information

THE thirtieth annual A.S.M.E. Mechanical Catalog and Directory, 1941 edition, published October 1 by The American Society of Mechanical Engineers, will be distributed to members of the A.S.M.E. during October.

According to the editors of the 1941 volume, it is the only book which covers the field of mechanical engineering so thoroughly. In its catalog section, manufacturers describe and illustrate their products that are of interest to mechanical engineers. This section is followed by a Directory which gives the user a practically complete and authoritative index to manufacturers of metals and alloys, power-plant equipment, power transmissions, instruments, materials-handling apparatus, aircraft power plants and instruments, foundry and machine-shop equipment, heating, ventilating, and air-conditioning machinery, electric motors and controls, equipment for process industries, pumps, fans, compressors, and many other types of mechanical apparatus. A page reference system in the Directory refers one to the catalogs for a description of the desired machine or equipment.

A 16-page insert describing all A.S.M.E. publications, such as power test, boiler construction, and safety codes, American Standards, fluid meters, engineering biographies, bibliographies, research reports, and manuals, is included in this volume for the ready reference of A.S.M.E. members and other users.

Brooklyn Polytechnic Free Courses for Engineers

NATIONAL-defense-program courses in tool design and punch and die design, primarily intended for employees in local industrial plants who seek advancement in these fields, have been added to the curriculum of the evening division of the Polytechnic Institute of Brooklyn. For A.S.M.E. members who can meet the entrance requirements, based on either educational or practical industrial experience, free tuition will be extended under the National Defense Program of the Federal Government, according to Dean Ernest J. Streubel. The courses will start around the last week of September.

1940 A.S.M.E. Memorial Biographies Sent on Request

MEMBERS of The American Society of Mechanical Engineers who wish to receive a copy of the 1940 Memorial Biographies of Deceased Members are requested to fill out and mail the accompanying form, or order by letter, addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

These Memorial Biographies, which will be published in October, will form a part of the Society Records Section of the Transactions as bound for library use. They memorialize the lives of members of the Society deceased within the last few years, in most cases prior to 1939. Memorials of those who have died more recently are still in preparation. These will appear next year or later, depending on ability to assemble within the time allowed all of the necessary details, some of which are secured under great difficulties.

A.S.M.E.
29 W. 39th St.
New York, N. Y.

Please send me a copy of the October, 1940, issue of Memorial Biographies.

NAME.....

ADDRESS.....

.....

A CODE OF ETHICS FOR ENGINEERS

THAT THE DIGNITY OF HIS CHOSEN PROFESSION MAY BE MAINTAINED, IT IS THE DUTY OF EVERY ENGINEER

1. To carry on his professional work in a spirit of fairness to employees and contractors, fidelity to clients and employers, and devotion to high ideals of personal honor.
2. To refrain from associating himself with, or allowing the use of his name by, any enterprise of questionable character.
3. To treat as confidential his knowledge of the business affairs or technical processes of clients or employers when their interests require secrecy.
4. To inform a client or employer of any business connections, interests, or affiliations which might influence his judgment or impair the disinterested quality of his services.
5. To accept financial or other compensation for a particular service from one source only, except with the full knowledge and consent of all interested parties.
6. To advertise only in a dignified manner, to refrain from using any improper or questionable methods of soliciting professional work, and to decline to pay or to accept commissions for work secured by such improper or questionable methods.
7. To refrain from using unfair means to win professional advancement and to avoid unfairly injuring another engineer's chances to secure and hold employment.
8. To cooperate in building up the Engineering Profession by the interchange of general information and experience with his fellow engineers and with students of engineering and also by contributions to the work of engineering societies, schools of applied science, and the technical press.
9. To interest himself in the public welfare and to be ready to apply his special knowledge, skill, and training in the public behalf for the use and benefit of mankind.

Approved by the Council of The American Society of Mechanical Engineers, December 5, 1932

CODE OF ETHICS—AVAILABLE FOR FRAMING

(Copies of Code of Ethics, $8\frac{1}{2} \times 11$ in., are available for framing. These may be ordered from A.S.M.E. headquarters at thirty-five cents each, or twenty-five cents each in lots of 25.)

A.S.M.E. MEMBERS PRESENT AT WEST VIRGINIA SECTION MEETING OF MAY 28

(Twenty-nine members and guests attended this meeting to hear F. Ullberg, Edward G. Budd Mfg. Co., give an interesting talk on the methods and developments used in the manufacture of light-weight trains. The lecture was illustrated with a group of colored slides.)

NEW SIXTH AVENUE SUBWAY IN NEW YORK CITY TO BE INSPECTED DURING 1940 A.S.M.E. ANNUAL MEETING

A. W. Weber Gets $2500 Sloan Fellowship, M.I.T.

AGAIN in 1940, a junior member of The American Society of Mechanical Engineers was selected for one of the Alfred P. Sloan Foundation Fellowships of $2500 each which enables the recipient to complete a special one-year course in economics and administration at The Massachusetts Institute of Technology. Arthur W. Weber, junior A.S.M.E. and assistant manager of the Wellsboro Plant, Corning Glass Works, Corning, N. Y., was one of eleven successful candidates who were selected from nominations made by 279 companies for this annual competition, the third of a series started in 1938. The A.S.M.E. junior who got a 1939 fellowship was Robert M. Zimmerman, project engineer, Transcontinental and Western Air Lines, Inc.

The program which the Sloan fellows undertake, begins early in June and covers a twelve-month period of lectures, seminars, individual investigations, and group visits to industrial plants. Any junior of the A.S.M.E. is eligible to become a candidate. Applications and substantiating records must be submitted to M.I.T. on or before March 15.

E.C.P.D. Lists Courses in New York and Vicinity

THE attention of young engineers in New York City and the surrounding region is directed to the many opportunities available for further study in the area's engineering schools by a list of 149 courses recently published and distributed by the Committee on Professional Training of the Engineers' Council for Professional Development. The list tabulates engineering, sciences, and nonengineering, both graduate and undergraduate.

With the Student Branches

A.S.M.E. Leads Other Engineering Societies With Record Student Membership of 6803

FOR the school year of 1939-1940, the 118 Student Branches of The American Society of Mechanical Engineers had a total membership of 6803, which exceeds that of any other engineering society in the United States and Canada. The student membership of the other Founder Societies for the same period was as follows: A.S.C.E., 5900; A.I.M.E., 3544; and A.I.E.E., 2950. Already the new officers of each A.S.M.E. Student Branch have plans under way to make it 7000 or more for the year of 1940-1941.

Colleges and universities which had 100 or more A.S.M.E. student members during 1939-1940 are Purdue 247, Armour 190, Illinois 188, California 173, Texas A. & M. 166, Minnesota 159, Pratt 135, Cooper Union 128, N.Y.U. 124, Newark 123, Case 120, M.I.T. 117, Brooklyn Poly 113, Michigan 113, Georgia Tech 112, Stevens 105, and Northeastern 100. The greatest gain in this group was made by Newark College of Engineering, which increased its membership from 81 to 123, a gain of 52 per cent. Close behind it is the University of Minnesota, increasing from 107 to 159 for a gain of 49 per cent.

Many of Newark's members were obtained during the first month of school. Shortly before the first meeting, each prospective member received a personal letter in which A.S.M.E. activities were described. This was followed by a series of "get-acquainted" posters placed on bulletin boards in order to further familiarize prospective members with the activities of the Branch. Minnesota got most of its members as a result of a membership rally at which free gifts were given to new members and of a "bean feed" at which prospective members were fed and entertained.

Chas. T. Main Award and Other Prizes Available to Students

THE American Society of Mechanical Engineers through the Committee on Relations With Colleges announces a group of awards amounting to more than $1200 available to student members during the school year of 1940-1941. Chief of the prizes is the Charles T. Main Award of $150 which will be given for the best paper on the subject of "The Need and Possibilities of Participation by Engineers in Public Affairs." Also available are two awards of $25 each, one for an undergraduate student and the other for a graduate student, for outstanding technical papers and theses.

All three of the prizes also entitle the winners to receive traveling expenses to and from the Annual Meeting of the Society at which the awards are made.

At each of the ten student conferences to be held this next spring more than $1000 in cash, and other valuable awards will be given to those presenting the best papers. Some of the Local Sections are planning to cooperate with the Student Branches in their areas in arranging contests at which cash or other prizes will be awarded Many of those who won prizes last year obtained excellent positions upon graduation because of their winning papers.

AT A.S.M.E. GROUP X STUDENT CONFERENCE, SANTA CLARA, CALIF., MARCH 29–30, 1940

[*Left to right:* S. R. Dows, C. F. Wieland, R. L. Daugherty (Caltech), G. H. Raitt, A. L. London, T. T. Eyre (Southern Calif.), G. L. Sullivan (Santa Clara), C. F. Garland (Calif.), and H. B. Langille (Calif.).]

FRIDAY LUNCHEON, A.S.M.E. GROUP X CONFERENCE, SANTA CLARA, MARCH 29–30, 1940

[*Left to right:* J. V. Crawford (Caltech), M. M. Tilley (Nevada), R. M. Bridges (Southern Calif.), G. L. Sullivan (Santa Clara), G. H. Raitt, G. T. Hayes (Calif.), W. T. Box (Santa Clara), A. M. McVicar (Arizona).]

Student Branch Secretaries

Please Note!

REPORTS of meetings and inspection trips must be received at Society Headquarters on or before the sixth of the month in order to appear in next month's issue of Mechanical Engineering. For example, all copy received up to Oct. 6 will be in the November issue, etc.

PHOTOGRAPHS of student-member groups are always welcome for use in Mechanical Engineering. Prints should be preferably glossy and of good contrast. However, send in everything you have and the editorial department will use those it can reproduce.

PUBLICITY is always good for the branch. Clippings from school and local newspapers should be sent in with your reports.

1940 M.E. Graduates Almost All Placed

COOPER UNION officials report that all mechanical-engineering students who were graduated in June 1940, have been placed. At Cornell University, more than 83 per cent of engineering graduates were assured positions by graduation day. Chemical engineers again led in percentage with 91.6, followed by mechanical engineers with 90.3, administrative engineers with 86.3, electrical engineers with 75, and civil engineers with 71.4. The Engineering Societies Personnel Service, Inc., in which the A.S.M.E. is a cooperating organization, reports that practically all mechanical-engineering graduates of 1940 registered with the Service have been placed.

President of United States Urges Youth to Stay in School

ACCORDING to information received from the Commissioner of the U. S. Office of Education, the President of the United States, in a letter dated August 14, said, "Reports have reached me that some young people who had planned to enter college this fall, as well

A.S.M.E. Student Group Meetings, 1940

GROUP I—NEW ENGLAND STUDENT MEETING, WORCESTER, MASS., MAY 3–4

Attendance: 172 Papers presented: 12

Prize	*Recipient*	*Title of Paper*	*College*
First	Ronald Brand	"Photoelastic Analysis of Three-Dimensional Stresses"	W.P.I.
Second	P. A. Hutchinson	"A New Type Water Brake"	Maine
Third	H. A. Rowe	"Air Turbines"	M.I.T.
Old Guard	A. L. Hardy	"A Knee Action for Autos"	New Hampshire
Fifth	Vincent Simeone	"Combustion-Gas Turbines"	Tufts

GROUP II—EASTERN STUDENT MEETING, NEWARK, N. J., APRIL 29–30

Attendance: 290 Papers presented: 18

Prize	*Recipient*	*Title of Paper*	*College*
First	Stanley Corrsin	"An Optical Method of Visualizing Low-Velocity Air Flow"	Pennsylvania
Second	R. S. Lovelace	"Ship Stabilization"	Princeton
Third	A. L. Trumpler	"Gas Turbines"	Lehigh
Old Guard	Jacob Pineles	"The Effect of Sintering Temperature on Tensile Strength of Iron Powder"	Stevens
Fifth	J. A. Oppel	"A Free-Hung Sailboat Centerboard"	Newark College

GROUP III—ALLEGHENIES STUDENT MEETING, COLLEGE PARK, MD., APRIL 25–26

Attendance: 346 Papers presented: 14

Prize	*Recipient*	*Title of Paper*	*College*
First	R. J. Bischoff	"New Developments in Automotive Hydraulic Transmissions"	Ohio Northern
Second	J. H. Sidebottom	"The Steam Turbine in Aircraft"	Virginia
Third	H. H. Deist	"Modernizing the Engineer"	Akron
Old Guard	W. B. Pritchard	"Earth-Moving Equipment"	Ohio State
Fifth	C. A. Meyer	"Automotive Hydraulic Couplings"	Case

GROUP IV—SOUTHERN STUDENT MEETING, BIRMINGHAM SECTION—ALABAMA POLYTECHNIC INSTITUTE AND UNIVERSITY OF ALABAMA, BIRMINGHAM, ALA., MAR. 31–APRIL 1–2

Attendance: 250 Papers presented: 15

Prize	*Recipient*	*Title of Paper*	*College*
First	C. H. Stanton	"Feedwater Regulation"	Florida
Second	C. D. Fulton, Jr.	"Gasoline Economy Tests"	Vanderbilt
Third	E. S. Foreman	"Multiple-Engine Power Unit"	Kentucky
Old Guard	W. Larsson	"Electric Arc Welding in Heavy Construction"	Duke
Fifth	G. H. Early	"Problems in Rice Milling"	Mississippi State

GROUP V—MIDWEST STUDENT MEETING, CHICAGO, ILL., APRIL 15–16

Attendance: 400 Papers presented: 16

Prize	*Recipient*	*Title of Paper*	*College*
First	W. H. Mashinter	"Mister! What's Your Gasoline Cost per Mile?"	Armour
Second	J. L. Slonneger	"Oil-Well Pumpings"	Illinois
Third	A. G. Thayer	"Measuring High Temperature"	Michigan State
Fourth	J. A. Jones	"Gasoline Misinformation"	Rose Polytechnic
Old Guard	R. B. Miller	"Explosion-Gas Turbine"	Iowa State
Sixth	Thomas DeFouw	"The Gyroscope"	Michigan College
Seventh	J. K. Bryan	"Unionization of Engineers"	Purdue
Eighth	Roy Decker	"Refrigeration for Automobiles"	Lewis
Ninth	Norbert Schickel	"Technological Advance and Employment"	Notre Dame

GROUP VI—NORTHERN STUDENT MEETING, KANSAS CITY, MO., APRIL 26–27

Attendance: 136 Papers presented: 15

Prize	*Recipient*	*Title of Paper*	*College*
First	F. A. Lang	"Air-Vapor Heat Map and Its Use"	Missouri
Second	F. R. Hunter	"A Model Water-Tube Boiler"	Kansas State
Third	F. L. Havel	"Enthalpy Shows Her Shape"	Missouri
Old Guard	Collins Thompson	"Effects of Secondary Air in Boiler Furnace"	Washington
Fifth	P. H. Koch	"Fluid Drive for Autos"	Nebraska
Sixth	James Nottingham	"Antiaircraft Defense"	Kansas
Hon. Mention	Harry Frech	"Measuring Atmospheric Dust"	Washington

GROUP VII—SOUTHWEST STUDENT MEETING, LUBBOCK, TEX., APRIL 19–20

Attendance: 135 Papers presented: 18

Prize	*Recipient*	*Title of Paper*	*College*
First	J. W. Wood	"Performance of Screen-Filled Cooling Towers"	Texas A. & M.
Second	Robert McCants	"Photoelastic Analysis"	Rice
Third	W. R. Woolrich, Jr.	"A Portable Quick Freezer"	Texas
Fourth	Howard Peck	"A Machine for Cleaning Castings"	Okla. A. & M.
Old Guard	T. A. Thompson	"Welded Gasoline Engine"	Arkansas
Sixth	R. M. Jones	"Gyroscopic Clinograph"	Rice
Seventh	B. J. Bartels	"LP Injection of Fuels"	Texas
Eighth	J. H. Cowan	"Cottonseed Oil as Fuel"	Texas Tech.
Ninth	O. R. Eads	"Research in Cutting Steel"	Oklahoma
Tenth	G. W. Wheeler	"Metalock"	Texas A. & M.

GROUP VIII—PACIFIC NORTHWEST STUDENT MEETING, MOSCOW, IDAHO—PULLMAN, WASH., APRIL 29–30–MAY 1

Attendance: 120 Papers presented: 11

Prize	*Recipient*	*Title of Paper*	*College*
First	I. L. Saunders	"Improvement of Reversible Axial-Flow Fans"	Oregon State
Second	Harold Jenseth	"A Small Steel Ship"	Washington
Third	Byron Acomb	"Lubrication Chart for Cast-Iron Spur Gears"	Washington
Old Guard	William Moats	"Fluid Drive in Autos"	Idaho
Fifth	B. B. Bullwinkle, Jr.	"Heat-Treatment of Cast Iron"	Oregon State

GROUP IX—ROCKY MOUNTAIN STUDENT MEETING, SALT LAKE CITY, UTAH, APRIL 19–20

Attendance: About 120 Papers presented: 10

Prize	*Recipient*	*Title of Paper*	*College*
First	James Adamson	"The Use of Plastics in Airplane Construction"	Utah
Second	W. B. Scott	"Unionization of the Engineer"	Colorado
Third	D. G. Bagley	"Scientific Management"	Utah
Old Guard	L. F. Wilkens	"Photoelastic Analysis in Design"	Colorado State
Fifth	Lincoln Elkins	"Particle Size Distribution"	Col. Sch. Mines

GROUP X—PACIFIC SOUTHWEST STUDENT MEETING, SANTA CLARA, CALIF., MARCH 29–30

Attendance: 73 Papers presented: 9

Prize	*Recipient*	*Title of Paper*	*College*
First	G. K. Woods	"Concrete Die Caster"	California Tech.
Second	Ralph Rhoda	"Performance of the Jet Pump"	California
Third	F. M. Booth	"Evaporative Coolers"	Santa Clara
Fourth	D. H. Steinmetz	"Reversible-Cycle Heating Systems"	California Tech.
Old Guard	R. M. Bridges	"I-C Engine Refinements"	So. California
Sixth	E. J. Cambou	"Hydromatic Clutch in Autos"	Santa Clara

SNOW STATUE MADE FOR 1940 WINTER CARNIVAL BY MICHIGAN TECH BRANCH WON THIRD PRIZE

as a number of those who attended college last year, are intending to interrupt their education at this time because they feel that it is more patriotic to work in a shipyard, or to enlist in the Army or Navy, than it is to attend college. Such a decision would be unfortunate. . . . . Young people should be advised that it is their patriotic duty to continue the normal course of their education, unless and until they are called so that they will be well prepared for greater usefulness to their country. They will be promptly notified if they are needed for other patriotic services."

National Safety Congress and Exposition, Chicago, Ill., Oct. 7–11

THE 29th National Safety Congress and Exposition, under the auspices of the National Safety Council and cooperating organizations, will be held in Chicago, Ill., at the Stevens Hotel, Oct. 7–11, 1940. Of particular interest to mechanical engineers will be sessions covering the following subjects: Aeronautics, engineering, automotive and machine shop, metals, and motor vehicles. Further information may be obtained from the National Safety Council, 20 N. Wacker Dr., Chicago.

N.C.S.B.E.E. Meets in Charleston, S. C., Oct. 28–31

THE National Council of State Boards of Engineering Examiners will hold its 21st annual convention in Charleston, S. C., Oct. 28–31, 1940. Complete information may be obtained from T. Keith Legaré, executive secretary, 503 Carolina Life Bldg., Columbia, S. C.

Welding Society to Meet in Cleveland, Oct. 20–25

ANNOUNCEMENT has been made by the American Welding Society that plans for its annual meeting, to be held in conjunction with the National Metals Exposition, Cleveland, Ohio, Oct. 20–25, are completed. Headquarters for all technical sessions, committee meetings, and social events will be the Hotel Cleveland.

American Engineering Council

Presents

The News From Washington and Elsewhere

Joint Committee Reports on A.E.C. Aims and Objectives

MONTHS of study of the basic aims and objectives of American Engineering Council, and of ways and means by which they may be best accomplished, have resulted in the submission to the American Society of Civil Engineers, The American Society of Mechanican Engineers, the American Institute of Electrical Engineers, and American Engineering Council of a report prepared by a special joint committee representing these organizations, pertinent parts of which follow.

The Committee is convinced that there is need for a strong national organization to be located in Washington to represent all engineers. The designation should continue to be "American Engineering Council," with its organization and functions modified in accordance with the recommendations included in this report. This organization would:

1 Act as a service organization to the existing national and local engineering societies, by continuing desirable activities of this character being carried on by the present A.E.C.

2 Carry out such matters now handled through joint committees of the Founder Societies as may be requested by them.

3 Aid in coordinating activities of the separate societies.

4 Suggest ways and means to eliminate and prevent possible waste resulting from duplication of effort by the existing societies.

The Committee does not favor any attempt to replace the present engineering societies by a single society.

Organization

1 The American Engineering Council should consist of representatives of the constituent bodies selected in much the same manner as they are at present, with an executive secretary located in Washington. The administrative authority should be an Executive Committee.

2 There should be created a coordinating committee primarily to serve as a clearing house between the executive secretary of Council and the Founder Societies. This committee should be composed of the national secretaries of the Founder Societies and the secretary of A.E.C. The committee should meet at intervals in New York.

Functions

As a continuation of its present functions, the Council should undertake the following:

1 Aid to the Federal Government. Upon receipt of requests for information or service from the Federal Government, including legislative and administrative branches, the Council should attempt to meet these requests by supplying: (*a*) Factual information; (*b*) engineering opinions, after first referring the requests, through the secretaries of the national societies, to existing committees, divisions, etc., of those societies, or to representative groups of individuals.

2 Aid to the engineering profession on governmental problems: This includes: (*a*) Interpretation for the member societies and their individual members, preferably through publications and releases, of Federal laws, rules, regulations, and practices, and (*b*) attempts to satisfy requests from the participating societies and their individual members for information about governmental matters and for service in Washington.

3 Public discussion: In cooperation with national member societies, the Council shall formulate and sponsor programs at convenient annual meetings or conventions on public problems relating to engineering. (A.E.C. sponsored a general session meeting at the Summer Convention of the American Institute of Electrical Engineers.)

4 Fact-finding investigations: Fact-finding investigations of national interest may be made upon approval of the executive committee either (*a*) upon request of member societies, which should finance any such requested investigation, or (*b*) on its own initiative. These investigations should be limited to problems which are essentially of an engineering character and should not include investigations of political subjects.

5 Annual conference of secretaries: The Council should sponsor annual conferences of secretaries of engineering societies on a self-sustaining basis. A number of successful conferences of this nature have been held during the last few years.

Suggested Activities

It is further recommended that, as and when occasion may arise and finances permit, the Council should extend its activities into enlarged or new fields to include:

1 Improving professional status through (*a*) the sponsorship of correlations of the "Code of Ethics" for engineers, and (*b*) support of unification in the licensing of engineers to promote reciprocity between states.

2 Aiding the profession through (*a*) the study of the possibility of standardizing contracts, contract bonds, and forms of insurance on contracts in connection with construction projects supervised by engineers; (*b*) sponsorship of studies or standardization of municipal building codes; (*c*) sponsorship of the representation of the engineering profession on temporary committees appointed by Federal agencies in Washington for special investigations; (*d*) studies of relations between the national, state, and local engineering societies; and (*e*) possible coordination of safety activities relating to engineering.

3 Aiding the national defense by studying

the possible contribution of the engineering profession.

The Joint Committee submitting this report was composed as follows: A.S.C.E.—Malcolm Pirnie, consulting engineer, New York City, Harold M. Lewis, chief engineer and secretary, Regional Plan Association, Inc., New York City, Sanford W. Sawin, project engineer, E. I. du Pont de Nemours & Co., Wilmington, Del.; A.S.M.E.—James W. Parker, vice-president, The Detroit Edison Company, Detroit, Mich., T. S. McEwan, management engineer, Stevenson, Jordan & Harrison, Chicago Ill., A. R. Smith, engineer, General Electric Company, Schenectady, N. Y.; A.I.E.E.—T. F. Barton, assistant manager, New York district, General Electric Company, New York City, H. S. Osborne, transmission engineer, American Tel. & Tel. Company, New York City, John C. Parker, vice-president, Consolidated Edison Company, New York City; and A.E.C.—John S. Dodds, professor of civil engineering, Iowa State College, Ames, Iowa, Gustav G. Requardt, consulting engineer, Whitman, Requardt & Smith, Baltimore, Md., and Henry T. Heald (alternate for H. E. Babbitt) president, Armour Institute of Technology, Chicago, Ill.

Executive Committee Meets

SOME idea of the extent and variety of matters currently falling within the scope of American Engineering Council's agenda may be gleaned from a brief summary of the minutes of a recent meeting of the executive committee. Subjects discussed included the following:

1 Consideration of letters received from the late Major William Bowie, executive secretary of the Society of American Military Engineers, and Samuel H. Ordway, Jr., president of the National Civil Service Reform League, containing suggestions for bettering present procedures for recruiting federal personnel, particularly in the professional and subprofessional grades. These were referred by the committee to Gano Dunn, Council's representative on the President's Committee on Civil Service Improvement.

2 Discussion of a study of engineering positions and salaries in private industry undertaken by the American Society of Civil Engineers in cooperation with several other societies. President Hammond was directed to confer with George T. Seabury, secretary of the Society, to see if this project might not be endorsed over to A.E.C.

3 Consideration of the action of the A.S.C.E. announcing its intention of withdrawing its support of Council at the close of 1940.

4 Formal confirmation of the appointment of Colonel L. B. Lent to the post of executive secretary.

5 A canvass of the committee for the names of engineers who might fill vacancies in executive positions with The Panama Canal, as requested by its director of personnel, Seymour Paul.

6 Consideration of a complaint from the Engineering Societies of New England that the Bureau of Yards and Docks, Navy Department, is executing contracts with contractors for the construction of air and naval bases including the provision of engineering services as well as construction. A formal protest against this action was voted.

7 Decided to use Council's facilities to call to the attention of member societies the desirability of using engineers as arbitrators in settling disputes between capital and labor.

8 Consideration of ways in which Council could cooperate with the Massachusetts Institute of Technology in a lengthy study looking to better integration of the building industry.

9 Discussion of a report by the Public Affairs Committee recommending the making and distribution by Council of phonograph records of noteworthy addresses in the field of engineering economics for playing before meetings of engineering societies, college classes, and discussion groups. No action was taken pending the determination of costs.

10 Considered a suggestion by Leonard J. Fletcher that Council aid in the formation of local engineering councils, such as was recently organized in Peoria, by suggesting to some prominent individual in each locality that he take the initiative in forming such a body.

11 Heard a report by President Hammond that he had requested the A.S.C.E. to file with Council a copy of its census of engineers, now being taken, so as to be immediately accessible to officials of the federal government.

12 Authorized the Committee on Engineering Economics to distribute to member organizations a report on economic balance as a means of stimulating discussion on some of the larger economic questions confronting the world today.

Funds Sought to Study Defense Inventions

THE newly organized committee to examine inventions useful in national defense, of which Charles F. Kettering, vice-president in charge of research for the General Motors Corporation is head, is seeking a fund of $150,000 with which to build up a staff of some 50 trained engineers, patent investigators, and other experts to carry out its objectives. These will include not only the investigation of inventions submitted to it by outside inventors, but also the assignment of unsolved defense problems to inventors and research organizations for study. It is anticipated that the money will be provided by Congressional appropriation, failing which it may be allocated from the President's special emergency fund.

Minneapolis Engineers Join A.E.C.

By action of the executive committee the application of the Engineers' Club of Minneapolis for membership in American Engineering Council has been officially approved, effective as of July 1, 1940. The new affiliate was first organized in 1883 and has been a member of the Minnesota Federation of Architectural and Engineering Societies since 1920. Officers for 1940–1941 are: President, Harold C. Evarts; vice-president, George C. Priester; treasurer, Karl Moulton; and secretary, Arthur F. Mellen.

Program Suggested to Help Pan-American Relations

FOLLOWING a conference with State Department officials, the A.E.C. Committee on Inter-American Engineering Relations, of which C. O. Bickelhaupt is chairman, has recommended the adoption by Council of the following program to aid in the development of cultural and other relations between engineers in the United States and other countries in the Western Hemisphere:

1 Foster additional scholarships in engineering schools of the United States for students from Pan-American countries, and the exchange of scholarships with such countries.

2 Establish in New York a headquarters for visiting engineers to help them in planning inspection trips to engineering projects and manufacturing plants, and in making travel arrangements.

3 Arrange for the exchange of engineering publications, information, and similar material.

The committee has further recommended that the executive secretary be authorized to work with the committee in carrying out these recommendations.

Committee to Consider Engineering Ethics

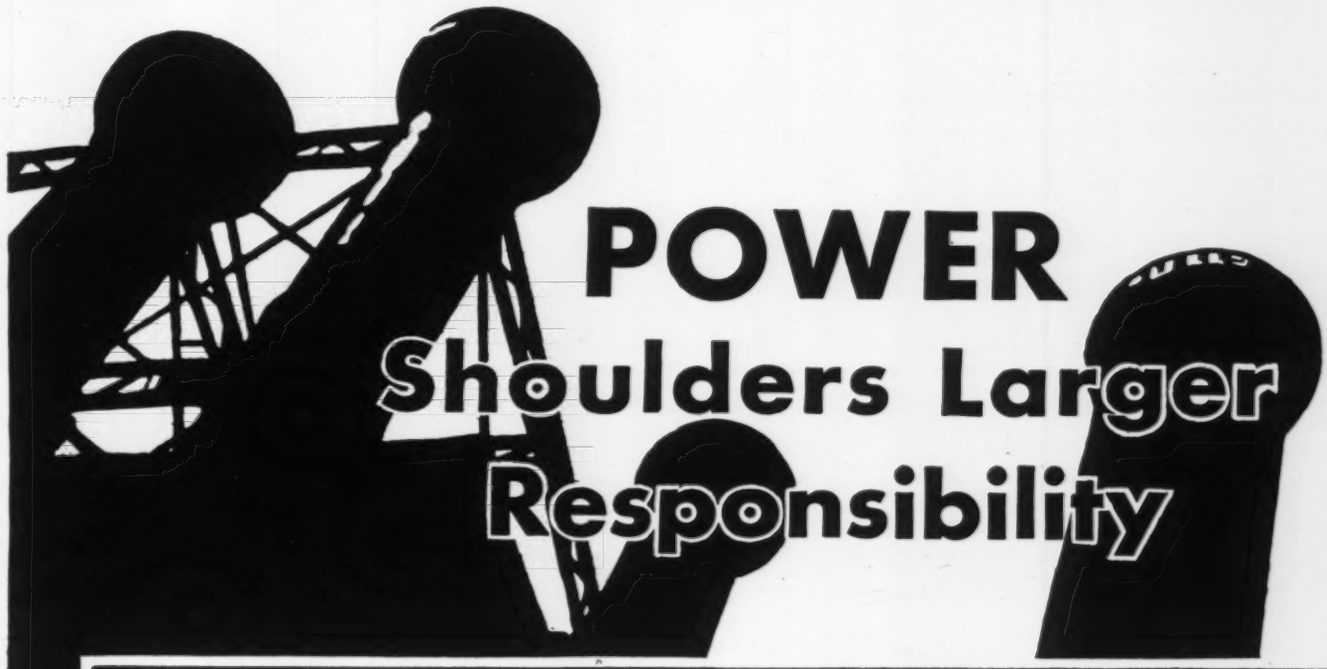
PREPARATION of a "Code of Ethics" for the engineering profession to form the basis for actions by member societies of American Engineering Council in adapting it to their specific requirements has been entrusted by President Alonzo J. Hammond to a newly formed committee headed by Dugald C. Jackson, professor emeritus, M.I.T., who will represent the A.I.E.E. and the A.I.C.E. Other members are: Dr. William H. Kenerson, Brown University, representing the A.S.M.E.; Arthur W. Dean, chief engineer (retired), Massachusetts State Planning Board, for the A.S.C.E.; and Dean J. W. Barker, Columbia University, for the S.P.E.E. Dr. Scott Turner will also participate as an observer representing the A.I.M.E.

Colonel Lent, Executive Secretary of A.E.C., Honored

OFFICERS of some of the national engineering societies and of District of Columbia sections welcomed Col. L. B. Lent, the new executive secretary of the American Engineering Council, at a recent luncheon shortly after he assumed office. Among those present were: Col. G. F. Jenks, A.S.M.E.; Prof. J. E. O'Brien, A.I.E.E.; C. A. Betts, A.S.C.E.; F. E. Spurney, A.S.H.V.E.; W. E. Reynolds, S.A.E.; Leo Cleary, N.S.P.E.; and M. E. Weschler, Washington Society of Engineers. Also present were a number of officers of national engineering societies.

President Alonzo J. Hammond of A.E.C. presided. Other Council officials attending, besides Colonel Lent, were Dean A. A. Potter, of Purdue University, and Dean Frederick M. Feiker, of George Washington University.

(A.S.M.E. News continued on page 772)



POWER Shoulders Larger Responsibility

Squarely on America's industries rests the success of this Nation's ability to thwart any threat to our peace and prosperity. Back of every preparedness step that Industry will take is the need for Power, for without modern power facilities every defense effort becomes futile.

In these conditions, this year's National Power Show assumes added importance. Here, under one roof, engineers can, in one short week or less, see the latest products... discuss needs and problems with engineers in attendance at exhibits . . . view demonstrations . . . discuss, compare, and select the latest and best equipment, materials, instruments, supplies and services for efficient power and steam generation, control, transmission and application.

Here, engineers alert to their responsibilities and opportunities will contact manufacturers to make sure that plant capacity can be increased as fast as required, and avoid production-clogging bottle-necks when prompt deliveries are no longer possible.

Admission is by registration.

More than 40,000 visitors are expected.

Engineers and executives with power interests are invited.

14th NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING..

GRAND CENTRAL PALACE · NEW YORK · DEC. 2-7, 1940

Management, International Exposition Co.

691

Men and Positions Available

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MEN AVAILABLE[1]

ENGINEERING ASSISTANT. Compressed-air, pumps, motors—sales experience; accountant; tax expert; middle-aged, energetic type. New York or Northwest. Me-528.

POWER ENGINEER, Stevens, fifteen years' experience operation, maintenance, and design steam-power plants. Excellent record in cost reduction through improvements in operation and maintenance. Continuously employed. N. Y. license. East or South. Me-529.

E.E., M.E. Married. 27 years' design, construction powerhouses, substations, distribution systems, industrial plants, executive engineering department large utility; purchases engineering equipment foreign interest. English, German, Russian, and oriental languages. Me-531.

WOOD TECHNOLOGIST, B.S., M.S., single, 27. Two years with woodworking plant, 160 employees; trouble-shooting, inspection, specifications, waste studies, research with adhesives, veneers, laminations, coloring, bending. Production, research, sales employment. Me-532.

SALES ENGINEER. Experienced in combustion and particularly utilization of gas in industrial-heating operations. Desires sales agency for product salable to industrial plants in New York and surrounding territory. Me-533.

MECHANICAL ENGINEER, M.E., Stevens, 28, single. Desires position as designing draftsman on machinery. Mathematical background, three years' drafting experience, one year as designer in steel mill. Now employed, desires change. Me-534.

EXECUTIVE ENGINEER with over 20 years' experience in design for economical production as well as development work covering diversified field of machinery. Has knowledge of mass production, cost, and sales. Good executive. Me-535.

MECHANICAL ENGINEER, 22, single, B.S. 1940. Honor graduate, believes hard work can somewhat offset lack of experience. Interested in design, does not shirk responsibilities. Will go anywhere in U. S. Me-536.

MECHANICAL ENGINEER, 26, married, Stevens 1935. Four years' experience general project work, economic studies, design, and development of factory methods. Now employed, desires change in position. Me-537.

GRADUATE MECHANICAL ENGINEER, 44. Specialist internal-combustion engines, diversified manufacturing and field training, consulting and lecture experience. Desires connection in commercial or engineering capacity with manufacturer, agency, or consulting engineers. Me-538.

MECHANICAL-ELECTRICAL ENGINEER, DESIGNER, 29, married. Four years pregraduate mechanic and electrician; five years responsible electrical and mechanical maintenance; one and one-half years successful inventive design. Travel; go anywhere. Me-539.

MECHANICAL ENGINEER, 37, Lehigh 1923. Production, power, and maintenance; varied experience in industrial, plant engineering. Registered professional and operating engineer. Me-540.

COMBUSTION ENGINEER, M.I.T. graduate. Sixteen years' experience design, operation of steam plants and wide knowledge of coals. Desires position with large coal producer, consulting engineer, or equipment manufacturer. Me-541.

MECHANICAL ENGINEER, 39, Pennsylvania registration, two degrees. College-teaching experience. Practice in selection of power-plant equipment, combustion engineering, and heat-balance problems. Proficient technical writer. Available now. Me-542.

MECHANICAL ENGINEER, Cornell. Twenty-three years' experience design, development, manufacture; automotive, industrial, and marine engines; compressors, pumps, clutches, gearing. Fifteen years' responsible charge. Inventive ability. Desires executive design position related field. Me-543.

AERONAUTICAL ENGINEER, 11 years' broad experience as chief engineer and project engineer, 9 years in charge of experimental and research work, designing special aircraft equipment, technical adviser, service acceptance trials. Me-544.

[1] All men listed hold some form of A.S.M.E. membership.

POSITIONS AVAILABLE

DEPARTMENTAL SUPERVISORS with technical or mechanical background and experience in supervision or real potentiality in this field. Salary, $185–$220 a month. Location, New England. Y-6235.

AUTOMATIC MACHINE DESIGNER, preferably with paper-converting-machinery experience. Must be American citizen. Salary open. New Jersey. Y-6236.

SALES ENGINEER experienced in sales of oils, greases, to call upon industrial plants, manufacturers of finished products. Must be thoroughly acquainted in this field so that he can recommend proper oil for machines. Must be American citizen. Salary, $200 a month. Territories open in Norfolk, Harrisburg, West New York, and Buffalo. Headquarters, New York, N. Y. Y-6239.

POWER DESIGNER OR PROJECT ENGINEER on steam-power plants, high and low pressure. Salary open. East. Y-6250.

ASSISTANT FACTORY MANAGER, 35–45, experienced in textiles, especially in weaving and winding work. This experience essential. Salary, $5000 year. East. Y-6251.

MECHANICAL ENGINEER, 25–40, preferably with experience with one of the large turbine manufacturers in engineering or service and erection department; capable of making inspection for insurance purposes on turbine generators and other heavy machinery; also with some experience in routine checking of electrical equipment, including motors and protective devices, to be located in the Middle West or South. Considerable traveling by company-owned car. Insurance experience not necessary but ability to handle himself with men in managerial positions in utilities and industrial establishments essential. Salary, $225–$250 a month. Headquarters, New York, N. Y. Y-6253.

HYDRAULIC DESIGNING ENGINEERS experienced in design of hydraulic presses. This experience essential. Men will be responsible for their designs. Must be American citizen. Salary open. Pennsylvania. Y-6261.

INDUSTRIAL MANAGEMENT ENGINEER, 45 up,

(*A.S.M.E. News continued on page 774*)

Civil Service Positions

Applications may be secured from U. S. Civil Service Commission, Washington, D. C., or any First-Class Post Office

MECHANICAL ENGINEER (industrial production), assistant to full grades, $2600 to $3800 a year. Requirements include a B.S. degree in engineering and certain experience. Maximum age is 60 years. Closing date is June 30, 1941.

MARINE ENGINEER, principal and senior grades, $5600 and $4600 a year. Optional branches for the senior grade only are: Power-plant layout and piping, turbines, boilers, Diesel engines, deck machinery, and general. Maximum age is 70 years. Closing date is June 30, 1941.

ENGINEER, junior grade, $2000 a year. Requirements include completion of a 4-year engineering course with major study in aeronautical engineering or naval architecture and marine engineering. Maximum age is 40 years. Applications will be accepted until further notice.

ENGINEERING AID (aeronautical), assistant to chief grades, $1620 to $2600 a year. Requirements include experience in testing, research, design, construction, or other engineering activities, partly in the field of aeronautical engineering. Maximum age is 55 years. Closing date is June 30, 1941.

ENGINEERING DRAFTSMEN, assistant to chief grades, $1620 to $2600 a year. These positions are for work on ships. College education may be substituted for experience. Maximum age for all grades except assistant is 60 years. Applications will be accepted until further notice.

AERONAUTICAL ENGINEER, assistant to full grades, $2600 to $3800 a year. Requirements include a B.S. degree in engineering and certain experience in aeronautical engineering. Maximum age is 53 years. Closing date is June 30, 1941. NOTE: No written examination required for any of Civil-Service positions listed.

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